1888

BULLETIN

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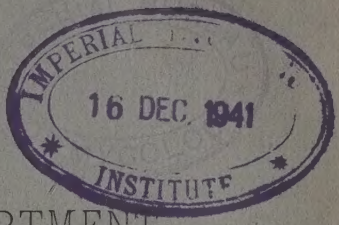

BOTANICAL DEPARTMENT,

OF THE

State Agricultural College

AMES, IOWA.

BYRON D. HALSTED, Sc. D. PROFESSOR OF BOTANY.

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FEBRUARY, 1888.

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PART I.

WORK WITH THE STUDENTS.

In this Bulletin is given an outline of the work in the Botanical Department for the college year ending November, 1887. Much of the class-work has been necessarily the same as that for the preceding year, which was outlined in the Bulletin for 1886.

FRESHMAN BOTANY.

The time over which the work with Freshmen extends has remained unchanged, but owing to the extremely dry summer the selection of subjects for study this year has been quite different from last season. The class begins the study of plant life late in July and closes it, for the college year, in November, and it was found best to hasten to a consideration of the flower before the blossoms of the better sorts, for beginners, were gone. Gray's Lessons were used as a text but the order of the chapters was much changed to accommodate the unfavorable circumstances under which the class labored. The work for each exercise was divided into three parts, namely: Class-work, field-work and book-work, and the requirements in each were fully stated upon the blackboard at each exercise. By class-work is to be understood the labor that was done in the class-room. This consisted mainly in the inspection of plants or portions of plants submitted by the instructor. Each student has a chair assigned, which is provided with a table-arm for holding plant, hand lens, paper for drawing, etc. The class averages about one hundred, and each student is kept busy for the whole hour in recording observations upon the specimens. Under field-work is included

the collecting and study of plants by the students outside of the class-room. The results of this work are brought to the class-room at the following meeting and submitted to the instructor along with the class-work of that day. Therefore there are two reports handed in by each student at each meeting. This method demands a good deal of the teacher's time out of the class-room; but by having the students leave the room in the order of their names on the class record, each placing his two papers in a box near the door, the time required to inspect the work and give the mark as required by college law, is brought down to the minimum. There is the satisfaction of holding each student to a practical study of plants which is not easy in any other way with such a large class. The class-work and field-work are carried on in connection with the book-work. The plan adopted may be better shown by an example or two. On October 6th the class-work was the study of an exogenous seedling. Each student was provided with a young bean plant ten days old, grown for the purpose in a box with others. The field-work following this was the study of a seedling endogen. Young corn plants were abundant at this time in the college garden. The book-lesson accompanying the above exercises was the growth of the plant from the seed. It will be observed that this chapter in elementary botany which logically should come early in the development of the subject was placed later. This change was one of those found necessary in order that the flower might receive treatment before its field illustrations were gone. The next exercise was as follows: Class-work—study short branch of balm of gilead, with large lateral buds containing the catkins for next spring. The field-work was a contrast of the buds of the lilac and the bramble, which also involved the subject of definite and indefinite annual growth. The text was "Lesson IV—Buds and Branches." The thought kept in mind is that of having the book-lesson follow the class-work and field exercise. This method induces a feeling of independent research and at the same time the exercise is not so prolonged as to lead to discouragement.

Written examinations were held at stated intervals and the whole text was gone over in review by recitations before the final examination at the close of the term.

During several of the exercises, while the chapters upon anatomy were under consideration, compound microscopes were set in the class-room and each student, in turn, looked at the preparations on exhibition. After returning to the seat a drawing was made of the objects seen. As high as four subjects in anatomy may thus be viewed and drawings afterwards made by the students. In this way a fair knowledge of stomata, pollen, ovules, ducts, etc., may be acquired. A class of a hundred can look into the microscopes in a single hour while the regular work of individual study of specimens of plants goes on without any serious interruption.

SOPHOMORE BOTANY.

The work for the first term of the Sophomore year was nearly as outlined in the Bulletin for last year. In the second term there was an additional examination, namely; upon the economic topics, which, as previously, were assigned to each pupil to look up from a list of library books. The questions for this examination were general ones, drawn from a set which had been given to the class some time before. The following are samples: What are the leading plants grown for their roots? Treat of commercial gums. What are the most important vegetable drugs? dye-stuffs? oils? gums? precious woods? tropical fruits? etc., etc.

Following this work upon the commercial products each student prepared a fifteen-minute paper upon a natural order. As the class numbered thirty-eight, all of the most important orders were included. At the same time that this work was going forward the students were spending three hours per week upon vegetable anatomy in the botanical laboratory.

The work done under the Topics of Research has been generally satisfactory this year. It is impossible to more than indicate the nature of the results obtained. One student made a catalogue of the wild plants of our ornamental grounds, finding one hundred and eight species distributed in thirty-four orders. The sleep of plants offered opportunity for many observations upon nyctotropic phenomena. Two pupils had studies in germination, one taking seeds of pumpkins and beans and the other

contrasted young corn and peas. A careful record of daily observations was kept, the idea being for the students to acquire a habit of making reliable experiments. The topic: Plants with two kinds of flowers was worked out in connection with Darwin's book upon this subject. The flora of dry beds of streams was an exceptional piece of field-work suggested by the season. A long list of plants was arranged, under the respective orders.

Two topics in difficult systematic work were assigned, namely: the genus Solidago, and the Asters. Good specimens of each species growing in the vicinity of the College were collected and mounted.

The following key to the local golden-rods was made out for use in classifying the species:

Heads axillary—

Plant grayish, with soft hairs.....S. bicolor, L.
Plant smooth, stem zigzag.....S. latifolia, L.

Heads in terminal compound corymbs—

Rough and hoary—leaves oval.....S. rigida, L.
Smooth—leaves keeled-petiole.....S. Riddellii, Frank.
Smooth—leaves 3-5 nerved, linear.....S. lanceolata, L.

Heads in one-sided racemes—

Leaves 3-ribbed.

Stem rough, hairy.....S. Canadensis, L.
Stem smooth—1-4 feet high, scales thick.....S. Missouriensis, Nutt.
Stem smooth—4-8 feet high, scales thin.....S. serotina, Ait.

Leaves not 3-ribbed.

Plant smooth { leaves lanceolate, rays 8-12.....S. arguta, Ait.
leaves broad, thickish, rays 6-9.....S. altissima, L.

Plant hairy { leaves broad, thin, rays 4.....S. ulmifolia, Muhl.
leaves spatulate, rays 6-9.....S. nemoralis, Ait.

Heads in racemes not one-sided—

Plant stout, leaves thickish, rays 5.....S. speciosa, Nutt.

In like manner the Asters of this region were collected and classified. Of the one hundred and fifty species in the United States Iowa has twenty-four and of this number fourteen are found in the vicinity of the College.

The following key was made for assistance in their identification:

Leaves silvery white.....A. sericeus, Vent.
Leaves not silvery white, 2.
2—Leaves clasping by broad base, 3.
Leaves not clasping at base, 4.
3—Involucre of one row.....A. Novæ Angleæ, L.
Involucre, more than one row, 5.

5—Plant smooth ..... A. lævis, L.
Plant not smooth, 6.
6—Rough, hairy, 7.
Glandular puberulent ..... A. oblongifolius, Nutt.
7—Rays ¼ in. long, amethystine or purple ... A. amethystinus, Nutt.
Rays ½ inch long, violet, stem purple ..... A. puniceus, L.
4—Lower leaves heart-shaped, 8.
Lower leaves not heart-shaped, 9.
8—Leaves entire, (or nearly) 10.
Leaves serrate, 11.
10—Stem erect, leaves rough ..... A. azureus, Lind.
Stem spreading, leaves roughish above, downy below ..... A. undulatus, L.
11—Branches diverging, scale tips obtuse ..... A. cordifolius, L.
Branches ascending, scale tips oval shaped A. sagittifolius, Willd.
9—Heads small, 12.
Heads medium sized, 13.
12—Scales spatulate ..... A. multiflorus, Ait.
Scales linear ..... A. Tradescanti, L.
13—Scales loosely imbricated ..... A. simplex, Willd.
Scales closely imbricated ..... A. tenuifolius, L.

Several of the topics assigned for special research required work with the microscope. The study of terminal buds was one of these. The whole inflorescence of the horse-chestnut was demonstrated in a bud by making longitudinal and transverse sections. Plant hairs was another subject which required work in the laboratory. For convenience in presenting the results the student divided all plant-hairs into those of flowers, of leaves, of stems and of roots. The seeds of cruciferous plants offered a special study of cotyledons as arranged in the seed. The student having charge of all abnormal forms of plants which were found, made a report of some length. Teratological specimens ranged from the common four-leaved clover to a five-spurred toad flax-flower. Abnormal foliage of an ash illustrated the compounding of leaves, one petelule, bearing several leaflets. Two flowers of an onosmondium were found fused into one, and a seven-forked spike of green fox-tail was recorded. Perhaps the most interesting deviation from the type was that found in the pistil of the Phlox pilosa, L. In this species, as in fact the whole order, (Polemoniaceæ) the ovary is tricarpellary. Instances were not infrequent where the ovaries and stigmas were four-merous. This being a variation in an ordinal characteristic, it suggests that a wider range may need to be given to this organ in the family

description. A number of albinoes were found, including Vernonia fasciculata, Michx. Cnicus altissimus, Willd. Trifolium pratense, L. Tradescantia Virginica L. and Verbena stricta, Vent.

Under dehiscence of fruits the pods and capsules of various plants were studied as, for example, those of impatiens, milkweeds, violets and poppy. Observations were made upon the sensitive stigmas of the common trumpet creeper (Tecoma radicans, L.) which were found to close in one minute, when most active, that is, with freshly opened blossoms on a bright, hot day. One student had the insect injuries of plants and found sufficient material for a long paper. The root system of the corn plant offered a special examination, with spade and shovel, of the under-ground habit of our leading field crop. A contrast was drawn between the tendrils of the grapevine and those of the cucumber. Another student answered the question, how does the Virginia creeper creep? The stipules of various plants were compared and the marked differences of these parts in closely related plants were pointed out. The leaf type of the giant ragweed (Ambrosia trifida, L.) was determined by examining three thousand of the multiform leaves of this species. An inspection of the polarity of the compass plant both as to the actual field observation and laboratory study of the structure of the leaf was a theme for one student. Another worked out in an experimental way the time required for some plants to ripen seeds. The common purslane needed ten days, the cultivated purslane fifteen days, and three times as long was not sufficient to mature the seeds of the common euphorbia (E. hypericæfolia, L.). The number of seeds upon three kinds of weeds was a practical subject which gave the following results: common dock, 7,556 seeds; black mustard, 16,416, and burdock, 36,456. The plants were average ones. The flora of a stubble field consisted mostly of members of the orders compositæ and gramineæ. In other words, sunflowers and allied plants with grasses, foxtail, etc., made up three-fourths of the plants, while in all there were thirty-five species in sixteen orders represented.

Among other topics of research may be mentioned: opening and closing of flowers; dispersion of seeds; five kinds of largest wild flowers; are our weeds mostly annuals? anatomy of the

milkweed flower; sensitive stamens of portulaca; compound leaves, unequal lobed leaves, etc.

It was not easy to hold each student accountable for all the work of the class under these topics, therefore the examination upon this branch of the term's work consisted in an inspection of the notes taken by each member upon the reports of all the others. This insured a record by each student of the important points in these separate reports of individual investigations.

A brief outline of the work done by the class in the laboratory is given. In way of preface it should be said that the students at the outset were entirely unacquainted with the use of the compound microscope and the first day or so was spent in making sections, preparing the objects for inspection and manipulating the microscope. The brittle stems of the common purslane are excellent for beginners in learning to make the sections. After these introductory lessons pollen was taken up and studied carefully. Drawings were required of all prescribed work. Several kinds of pollen were drawn. The flower of the common thistle (Cnicus altissimus, Willd.) in all its parts, proved a good subject. The filaments are sensitive and the class gained some knowledge of these peculiar organs. The stem of the richweed (Pilea pumila, Gr.) furnishes excellent material in which to study the fibro-vascular bundles. The course of each bundle may be easily seen from the outside of the succulent skin. Duckweed (Lemna polyrrhiza, L.) was a favorable subject for the root-caps, and crystals of various kinds in the cells of the flat leaf-like stem. The hairs of the squash were studied for the plant cell, protoplasmic movements, nucleus, nucleolus, etc. A comparison of the stomata of cabbage, corn, lilac, pine and barberry was made and also of the internal structure of the leaf of the stone-crop, lilac and compass plant. Exogenous stem of purslane, and maple; exogenous stem of young corn and asparagus; pine wood, medullary rays, crystals, starch, cork, latex tubes, sieve cells and the mucilagenous modification of the cell-wall of the outer coat of flax-seed are the other topics of most importance embraced in the laboratory work.

JUNIOR BOTANY.

The course in advanced botany with the Junior class began with the lowest forms of plants. Eight weeks were consumed in passing from the bacteria, through various orders of moulds, mildews, rusts, and smuts up to the mosses, ferns, and finally the lycopods. The class work of the second half of the term was confined to vegetable physiology. The following are the subjects studied in the laboratory during the term and in the order named: Bacteria termo and other species, yeast, Protococcus, diatoms, Peronospora (conidia and oospores), Cystopus, Exoascus, several species of erysipheæ (conidia and perithecia), ergot, black-knot, florideæ (tetraspores, antheridia and cystocarps, Puccinia graminis, Per. in its three forms (æcidium, uredo and teleutosporic,) lichens, fern prothallia and spore-cases, Equisetum, pollen tubes, embryo-sac and young plant, continuity of protoplasm.

The work upon the marine algæ was very satisfactory. Material from both the Atlantic and Pacific Ocean had been secured, so that classes may do a considerable amount of work with algæ, especially the florideæ.

Applied Botany.—In the required botany of the second term of the Junior year of the Agricultural Course the scheme of lectures of last year was followed with some variations in the laboratory work. The classification of native and cultivated grasses was added and particular stress was laid upon the provision for cross-fertilization among cultivated plants. Fruit and leaf buds were also studied, near the close of the growing season.

SENIOR BOTANY.

In addition to the work outlined in the last Bulletin there are three senior courses of special instruction. In the Veterinary School the Seniors are given one lecture per week upon that portion of botany which is most nearly related to their future work. The subject of Bacteria is made a chief feature and is approached by lectures and laboratory work upon the higher cryptogams. As these students have not received any previous laboratory instruction in botany this work opens with a study of pith, leaf cells, plant hairs, sections of stems, etc. After a sub-

ject like pine wood is mastered the class begins its work with cryptogams by studying spore-sacs of ferns and equisetum. A day is given to the florideæ after which the various smuts, rusts, mildews, and ergot are taken up. These are followed by yeast and finally by bacteria, several of which are studied as well as the methods of their culture and the sterilization of liquids. In connection with this latter work, and partly as a relief to weary eyes, pollen, circulation of protoplasm and other kindred subjects are investigated.

A second Senior course is with the students in Civil Engineering. This is nearly all laboratory work and is called Structure of Woods. The student begins with the simplest structure—the single cell, as the yeast plant, pollen-grains, etc. These are followed by cells in chains making filaments, as the common pond scum and plants with thin tissue, shown by the moss leaf or foliaceous sea weeds. Next pith is taken up and from this weak substance the student passes on by degrees until the stout stems of higher plants are reached. The young asparagus stem discloses endogenous arrangement and following this is the exogenous structure as shown by the purslane stem. From this time on the student acquaints himself with the peculiarities of pine, oak, chestnut and maple wood, sap and heart wood, bark, medullary rays (silver grain), etc. Under decay of timber various moulds, mildews, and other fungi are examined separately and afterward as found within woody tissue. Particular attention is given to yeast and bacteria as these are the agents which usually begin the work of fermentation and decay of timber. Lectures upon our timber trees and their distribution are given. The relative weight, flexibility, and fuel value of the leading timbers are pointed out and the most approved methods of preserving woods from the ravages of insects and fungi and other agents of decay are dwelt upon in connection with the microscopic work.

The third line of Senior botany is in the Agricultural Course, and upon the Diseases of Plants. The work for the past year has been divided as follows: One lecture, one field exercise and one afternoon in the laboratory per week. The lectures have been principally explanations of outlines of classification of fungi placed upon the blackboard. The next exercise required the student to spend three hours in collected diseased

specimens of plants. These collections furnished the material, or a part of it, for the laboratory work which soon followed in the same week. Various books upon fungi are close at hand during the laboratory hours and frequent reference is made to the herbarium which contains several thousand named specimens of fungi. About the middle of the term, after the student's eyes have become trained, an order is assigned to each member of the class and special attention is thereafter paid to a single group, upon which a paper is prepared and presented to the class at the close of the course. Special attention is given to diseases of cultivated plants, but those upon wild plants are not overlooked as they aid materially in comprehending the pathology of important economic subjects.

PART II.

OBSERVATIONS AND EXPERIMENTS.

The past year has been an exceedingly dry one and the rainfall for six months, beginning March 1st and ending September 1st, was only 8.32 inches. This includes the growing season and is only a small fraction of the average amount of rain which falls during the spring and summer months. According to the weather record kept at the College, and kindly furnished me, by my colleague, Professor Osborn, the showers in time and amount were as follows:

March	5	.10 inch	July	16	.02 inch
"	27	.56 "	"	17	.02 "
April	22	.75 "	"	18	.30 "
"	25	.51 "	"	19	1.45 "
"	26	.02 "	"	22	.13 "
May	14	.16 "	"	30	.41 "
"	22	.08 "	August	5	.23 "
"	29	.15 "	"	9	.11 "
June	6	.02 "	"	10	.08 "
"	11	.20 "	"	18	.09 "
"	12	.43 "	"	20	.40 "
"	13	1.16 "	"	21	.08 "
"	20	.23 "	"	26	.10 "
July	13	.45 "	"	30	.08 "

By month this gives for

March	.66 inches	June	2.04 inches
April	1.28 "	July	2.78 "
May	1.39 "	August	1.17 "

It will be seen that this is an average of only 1.39 inch per month and a total of 8.32 for that half of the year when rain is most essential for the existence and growth of vegetation. This prolonged drougth was made more intense by the preceding dry year. It was in fact the second of two comparatively rainless seasons. September opened with refreshing showers and by the close of the month the rain fall amounted to nearly ten inches (9.77).

PLANTS AND DRY WEATHER.

The general effects of drougth upon vegetation are quickly

stated. Herbage of all sorts was greatly dwarfed, especially upon the upland areas. It seemed as if the plants realized the danger they were in and expended much of their limited forces in producing flowers and maturing a few seeds. All forms of vegetation were pushed ahead of their natural time, as if spurred on by the sharp, hard barbs of necessity. Plants that ordinarily came into good condition for class use in botany about the first of July were ready by the middle of June, and students who did not procure specimens when first in bloom often failed in securing them. The pomologist says of some varieties of pears and other fruits that they need to be gathered and eaten with watch in hand. The same was true of many prairie flowers the present year. Specimens that ordinarily are in good condition for collecting for a whole month, ran their course of blooming in a single week.

Amidst all the trouble and disappointment which the drought brought upon the specimen-hunter and herbarium-maker, there was nevertheless a ludicrous side to help him forget the sad havoc which a scarcity of water produces upon the fair blooming face of a rich prairie soil. It might almost provoke a smile to pass along a by-way, that is usually shut in by high hedge-rows of the giant ragweed or horse-weed (Ambrosia trifida, L), and look down upon a sea of thickly set plants, perhaps six inches high and all with their spikes of inconspicuous flowers. It was a struggling burlesque upon former greatness. Think also of the evening primrose (Œnothera biennis, L,) which under favorable conditions runs up ten feet and bears hundreds of pale yellow flowers in the long close spikes, and then see this same species reduced to much less than a foot in length and with but a single flower and that so dwarfed that it, at best, only gives the student a clue to the species. The rank pasture thistle (Cnicus altissmus, Willd.) which in rich, moist soil becomes a stout weed covering several square feet of soil, was often so small that it was with difficulty that the hand could find the short stem below the single dwarfed inflorescence. It almost literally bloomed from the turf and possessed the characteristics of Alpine plants and those whose lease of life is one long struggle under adverse conditions.

Any amusing feelings which these dwarfs may at first

induce will turn to sadness as one contemplates the battle that was going on. It was a Gettysburg among the plants and in the thickest of the fight only the most enduring were able to hold out to the end. Even then they were weakened in constitution and years may pass before the old condition of things is restored.

A prairie soil is a remarkable one. None other can hold its vegetation as well under such trying circumstances, and nowhere else do the recuperative forces act so rapidly and effectively. Large areas surrounding the College on September 1st were covered with a seemingly lifeless herbage, but within a week nearly six inches of rain fell and five days later green began to replace the brown. A few days later there was fresh pasturage for the half fed live stock. The deep, black soil filled with accumulated vegetable matter holds the rain as it falls and yields it up reluctantly to the sun and air by evaporation.

One of the leading lessons of the season is that deep rooted plants with limited areas of leaf surface are the best to withstand the destructive agencies of drought. A shallow-rooted annual was quite sure to die out before the perennial which sends its roots down into the subsoil.

There are exceptions which need to be explained upon some other basis. Some plants revel in dryness and heat while others thrive only when they are continually surrounded by water at a low temperature. It is not for us here to discuss these marked illustrations of adaptation brought about by long ages of association. We know that the plants of the sea flourish only in the salt water of the ocean and many of the Alpine species are at home only when struggling for a foothold on some mountain side surrounded by the cold and rarified atmosphere of a high altitude. It may be that these latter would do well in the warm, fertile valley if stronger plants did not there stand ready to crowd and subdue these non-belligerent, hermit-like and hitherto unmolested mountain forms. We are prone to forget that any good situation for plants is constantly sought and it is held by those forms of vegetation best adapted to the conditions that there obtain. The lone cactus tree on a New Mexico desert is not crowded out by its neighbors because its surroundings are unfavorable to neighborly ideas.

The manner in which the purslane accepted the situation was far from gratifying to the gardeners. It practically had the field to itself and made the most of its opportunities. The hot sun and dry soil were not able to curl the plump leaves or cause the thick, succulent, prostrate stems to show signs of flagging energy. The plants hugged the earth all the more closely, and quickly developed a living mulch to aid it in further conquests. Great trouble was experienced in getting reinforcements when any member fell under the passing cultivator or stroke of the hoe. The surface soil was too dry to admit of the seeds germinating except at widely separated intervals when small showers fell. At such times new recruits came forward promptly and filled the gaps or covered freshly tilled areas with a purplish coat of seedling weeds.

As a rule, weeds have become so accustomed to unfavorable conditions that they are fortified for hard times, but excepting the purslane they made a poor growth during the past season and many of them gave up the contest early in the year. But little was seen of the shepherd's purse, peppergrass or any number of that family excepting mustard and charlock, which held out in a much dwarfed condition in some of the least dry situations. After the September rains these weeds sprang up rapidly and covered fields where, for example, Hungarian grass as a relief crop, had failed. The hoary verbena (Verbena stricta, Vent.) was a striking illustration of endurance. It might have been seen any day in the otherwise almost lifeless August pasture with its gray leaves and spikes of blue flowers, a standing evidence that the poorest herbage for live stock is often the kind to suffer least in times of distress. Another plant made conspicuous by the drought was the carpet weed (Mullugo verticillata, L.) This prostrate cousin of the chickweeds spread its fine stems over the hot, dry sandy places where nothing else could grow, and flowered and fruited there in a remarkable manner.

The compass plant (Silphium laciniatum, L.) became conspicuous upon the native prairie sod, not for any luxuriant growth of its own, but because nearly all else had lost its accustomed greenness. This large, coarse plant was much reduced in size and greatly changed in appearance. Instead of the leaves being

large and much cut, or laciniated along the edges, with large openings in the center of the blade, they were reduced to the frame-work with only their edges of pulp along the sides of the great veins. Ordinarily the leaves are broad and frequently without any open spaces, but during the present year none of the latter sort were found. Observations were made upon the polarity of the plant and it was evident that the "skeleton" leaves did not hold the relation to the points of the compass that obtains with the broad leaves of ordinary seasons. The size and peculiar construction of the compass plant leaves renders this silphium remarkably susceptible to the influences of surrounding conditions.

Among the cultivated plants the blue grass (Poa pratense,L.) showed great vitality, but none of the grasses or other forage plants withstood the drought with anything like the degree manifested by the red clover (Trifolium pratense, L.). Upon the college campus where this species abounds there was a daily testimony of its ability to live and grow when all else around the green tufts was as brown and lifeless as in early March. The habit of rooting deeply had doubtless been the safe anchor of this, the chief among American forage plants. Although its growth was small it nevertheless kept on and blossomed, forming small oases amidst a desert of dry herbage. The red clover has gained many lasting friends and although it is not recommended for lawn use the writer is thankful he watched it struggle successfully week after week to the end of the most severe drougth Central Iowa has ever known.

Another cultivated plant with remarkable tenancity of life under the trying circumstances, was the field Indian corn. In most places when it was able to get well established it continued to make fair growth. The leaves may have rolled up like cinnamon bark but they did not die, so long as the deeply penetrating roots could find moisture in the subsoil. A crop of both fodder and ears formed in regions where surrounding meadows did not produce a blade of grass long enough to mow. Corn has a remarkably accomodating root system. When the soil is moist the roots keep near the surface where the absorbing rootlets are warmed by the daily sun. In this we see the subtropical nature of the plant asserting itself. It needs to make

all of its extensive growth within the short period of four months or less, and for this much heat is demanded. When the soil is dry the roots take a downward course and spread out in a lower, because moister, layer of soil. This subject has been the special study of some students the past season and they find that the character of the root system of the plant is certain evidence of the conditions under which the plant has grown. We have here a proof of the importance of deep and thorough tillage as a favorable adaptation of soil to plant growth in times of extreme dryness.

The September rains came too late for any manifest effect upon a large share of the plants, but the response to the revivifying influences was quick in the grasses, except in places where a combination of drought and infesting insects had caused the death of the roots. Among wild plants the violets (Viola palmata var cucullata, Gray, and Viola pubescens, Ait.) flowered in such abundance in October that large botany classes had the blossoms for analysis and study. Anemone dichotoma, L., was another spring flower which appeared in quantity after the Autumn rains. Oxalis violacea, L., and Oxalis corniculata var. stricta, Sav., also blossomed freely in October. Many of the plants started up regardless of the unseasonableness of the time and would have blossomed had not the frosts put an end to their untimely development. Among some of the more striking freaks of the exceptional season were flowers and large fruit at the same time upon crab apple trees and spring-like blooms among the old foliage of the common garden snow-ball in late autumn.

SUBJECTS FOR PROTOPLASMIC MOVEMENTS.

Besides the subjects usually employed in the laboratory for the illustration of the circulation of protoplasm, such as the hairs of squash, tradescantia stamens, and corn silk, the following have served a good purpose and in some cases were better than the above standard plant structures. The hairs near the base of the corolla of Mertensia Virginica, D C., exhibit a streaming of their protoplasmic contents which is more rapid than that seen in the squash hairs. Near the base, also, of the corolla tube of Phlox

divaricata, L., are slender hairs which demonstrate cyclosis and were repeatedly employed by students in the laboratory. This is a common prairie pink, and is counted as a valuable addition to our material used in the practical study of vegetable physiology.

In like manner the stamen hairs at the base of the filaments of the common toad-flax (Linaria vulgaris, L.) are useful for the same purpose. As this plant comes after the pink has finished flowering it is all the more important. The trigger-hairs upon the sensitive filaments of the pasture thistle (Cnicus altissimus, Willd.) when taken while the flower is freshly open, furnish excellent mid summer material for the study of protoplasmic movements within living cells. Later in the summer, and forming, with the above three, a series of available subjects throughout the growing season, is the blue lobelia, (Lobelia syphilitica, L). The hairs upon the stamens of this late blooming species illustrate interesting and rapid movements within the cells. In addition to the above, the hairs upon the base of the petals of both Viola palmata, L., and its variety cucullata, Gray, exhibit the same changes in cell contents. This species often blooms in late October and therefore the list of flowers here given will furnish subjects for study, in the line indicated, from early spring until late autumn.

The coma of the common milkweed (Asclepias Cornuti, Dec.) when carefully removed from a fully-grown green follicle will exhibit the movements of the cell contents along the slender hairs. Asclepias incarnata, L. illustrates the same interesting circulation.

Root hairs of seedling plants are often good subjects in this respect. It has been found, for example, that the movements are rapid in the root hairs of red clover seedlings. The same is true of the young white mustard and timothy plants. The rhizoid-hairs of the prothallia of the horse-tail, (Equisetum arvense, L.) are particularly good for study of the protoplasmic movements, and the plants may be easily grown for use by sowing the ripe spores upon moist earth in a flower pot.

Several kinds of pollen exhibit the circulation of their fluid contents, either in the grain itself or the tube which may be forced from it by culture in a weak solution of sugar. Several of the grasses produce pollen with the contents forming a lace work

of threads in which a distinct streaming may be observed when the grains are looked at dry under the high power of the microscope. The nuclei are very distinct in each grain when made plump by adding water. No coloring of any kind is required to make them visible. The garden mallow (Hibiscus Trionum, L.) is especially favorable for showing the circulation of the contents within the tube of the pollen grain. Portulaca grandiflora, L. and the great bellwort (Uvularia grandiflora, Smith.) are useful as the tubes are easily obtained, are large and the contents coarse granular, thus making observation easy.

GERMINATION OF CUCURBITACEOUS PLANTS.

The method observed by many cucurbitaceous seedling plants in removing their coats in germination has been under investigation during the past two years. As a rule the seeds of this group are large. Those experimented with have varied from 5 m. m. in the gherkin to 27 m. m. in the seeds of Hubbard squash. A good sized seed of the latter weighed eight grams, and balanced 93 seeds of the gherkin. The variations in weight were no greater than those in the general shape and color.

The early Jenny Lind muskmelon is 10 to 12 m. m. long; the nutmeg is about one-third larger every way, while the improved canteloup is midway between the two; all three are straw-colored. The improved long green cucumber has a large drab-colored seed, more slender but about as long as the average muskmelon seed; it is lighter in weight. The early Russian is about the same, while the gherkin is only one-eigth the size, but of the same shape and color. The peerless watermelon seed is flat, dull straw or ashy-colored and nearly circular, with a furrowed border. Landreth's boss has a large seed (18 m. m. long) with chocolate granulations upon a light background, giving the seeds a "calico" appearance. The citron has seeds without evident furrows to the edges. It is more like cucumber seeds, but four times as heavy, and of a light cherry color. The yellow-bush scallop squash has thin oval seeds with a sharp point and distinct border. These seeds are usually somewhat twisted, so that the flat side does not lie close upon a level support; they have a dull straw color. Winter crook-neck squash seeds are of medium size (10 by 17 m. m.) straw-colored upon the furrowed border, and white upon the flat

faces; they are very variable in size. The Hubbard has beautiful, velvety, large, white seeds which are somewhat lenticular in shape; the slightly straw-colored border is narrow. Seeds of the nest-egg gourd have an ashy color, are thin, much warped, and about 9 by 12 m. m. The dish-cloth gourd has seeds which might be easily mistaken for small water-beetles. They vary from gray to black, are plump, shiny and have a pair of small projections near the end bearing the scar (hilum). In the Hercules club gourd the seeds are irregular and about 20 m. m. long; the border groove is midway between the edge and center of the seed, and at the free end are two horn-like outgrowths with a thick fur upon them. The color of the whole seed is light brown. The dipper gourd is much like the last, but somewhat smaller, lighter colored and with the horns less prolonged sidewise. The felt is thick and silky upon the "horns," and extends back along the furrow to the micropylar end of the seed. There is seen to be a wide range in the outward appearances of the seeds belonging to the cultivated sorts of the gourd family of plants.

We have only one wild member of the gourd family growing in this vicinity (Ames, Iowa,) namely the wild cucumber (Echinocystis lobata, T. & G.) This has large, long, smooth, slender seeds the mottled exterior colorings of which suggest some species of beetles.

For testing the time required for the germination of these various seeds, a shallow box 20 by 36 inches and three inches deep was filled with rich prairie soil, and placed upon the table in the laboratory. The different kinds of seeds were sown in as many rows as follows: (1) peerless watermelon; (2) Landreth's boss; (3) citron; (4) early Russian cucumber; (5) Improved long green cucumber; (6) gherkin; (7) dish-cloth gourd; (8) nest-egg gourd; (9) dipper gourd; (10) canteloup muskmelon; (11) early Jenny Lind muskmelon; (12) nutmeg muskmelon; (13) winter crook-neck squash; (14) yellow-bush scallop squash; (15) Hubbard squash; (16) Hercules club gourd. The last is so placed because it came a few hours after the original order for seeds had been received and sown. All the seeds here employed were kindly supplied by the Iowa Seed Company. The sowings were made on the afternoon of April 9th, 1887, and the first ground

was broken four days later on April 13th. The following table indicates the relative

RAPIDITY OF GERMINATION.

No. of kind.	April 13	April 14	April 15	April 16	April 17	April 18	April 19	April 20	April 21
1									1
2									2
3								1	1
4		6	7	7	9	9	9	9	9
5	5	7	8	9	9	9	9	9	9
6			1	1	1	2	2	5	5
7					1	1	1	2	2
8		3	6	6	6	6	6	6	6
9			1	1	1	1	1	2	2
10			2	4	6	6	7	7	7
11			1	3	5	5	5	5	5
12				3	5	5	5	5	5
13			3	4	5	6	6	6	6
14			2	3	5	5	6	6	6
15					3	4	4	4	4

16 One on April 28th.

It should be said that this table does not attempt to represent the vitality of the various sorts in a comparative manner, for in many varieties the number of seeds was limited to six, while with a few, as in cucumbers, the space admitted of a dozen seeds being sown. The prompt response of the two cucumbers proper (Nos. 4 and 5) to the conditions furnished, is marked. It is quite evident that the soil and air and water were not sufficiently warm for the watermelon seed. If we had no other facts in the case this experiment would throw light upon the influence of different degrees of heat upon the germination of cucurbitaceous seeds. The watermelon seeds start slowly, if at all, under conditions seemingly satisfactory for the development of cucumber seedlings. The gherkin, dish-cloth gourd and the dipper are all nearly alike as to time, and their subsequent growth indicated that the "season" was not far enough advanced for their best growth. In other words, the April soil, although it had been heated over a fire for hours until it was unbearable to the hand, was not in good condition for these comparatively tender seeds. The nest-egg, canteloup, nutmeg and all the squashes were slow but sure. By the 18th, nine days after sowing, these rows had a fine showing of healthy plants. The last and slowest of all was the Hercules Club gourd, which, with its large, thick coated seeds, did not make any appearance above the soil until the 28th of the month, or 19 days after the sowing was made.

These various sorts of related plants, as they grew in the box,

offered many interesting contrasts in size, shape, color and general behavior of the different parts. Some, like the cucumbers, had slender stems, and long, narrow cotyledons which were in strking contrast with the short, "thick-set" habit of the squashes, both as to stem and to leaves. The difference in size was particularly noticed between the Hubbard squash and the tiny gherkin. The gourds as a rule had very short hypocotyls, and large, broad seed leaves. In the nest-egg, for example, the expanded cotyledons were fully an inch long and a halt by an inch broad before signs of the plumule were manifest between them. In striking contrast with the large size of these leaves, the stem bearing them was remarkably small and only one inch long.

But all that has thus far been said is only preliminary to the investigation that was in mind, namely, the study of the removal of the seed-coats in cucurbitaceous plants.

The plants under consideration all provide themselves in germination with a special structure, developed when needed, to aid in removing the thick coats which their seeds possess. These pumpkin pegs, as they are termed, were treated at length in the last bulletin, page 30.

In germination the cucurbitaceous seed has its thick outer coat split at the micropylar end, and the primary root is forced out and downward. At the same time there is a lateral growth of tissue forming a cellular lip or "peg" as Darwin calls it. This peg is located upon the hypocotyl at a point where its lower surface, that is, the one toward the root end of the seedling, is applied against the inner surface of the inner coat. This inner coat is quite thin, but made up of cells which are firmly united, thus producing a tough and flexible covering to the embryo plant within. As the peg develops it exposes a thick layer of fine branching hairs upon the side close to the inner coat, while the opposite or free surface of the lip or peg is smooth and free from all hairs. Each of the outgrowths from the epidermal layer of cells of the lower surface of the peg is irregular in outline, often tortuous, frequently abounding with small disc-like projections, and the extremities are club-shaped. The basal half of each hair is thick walled, and seemingly empty, while the younger and exposed irregularly branching part is filled with granular protop-

lasm, which in its disposition and contents is identical with similar structures where glandular exudation takes place. This hairy surface of the peg becomes closely fastened to the inner coat, and as this coat is in close contact with the thick outer covering throughout its whole surface, it is easy to see that the peg in question has a firm attachment to the seed-coats as a whole. As soon as this peg has been developed and its attachment to the coat is secured, the seedling is in readiness to extricate itself from the thick and now worthless covering. The root continues to strike downward into the soil for support and anchorage, and produces lateral roots at many points on its way. The portion of stem above the peg, and between it and the cotyledons, which until now has been in comparative repose, begins to elongate. As the increase in length of this part of the stem continues, a loop is necessarily produced, the sharpest curve of which is outward from the seed-coats and upward from the peg. By continuing this elongation it is evident that so long as the peg holds on to the seed coats the only part to give way is the cotyledon and as the result these seed-leaves are slowly and effectually withdrawn from their coats. Before this desired end is reached, the loops may extend an inch or more above the seed-coats. In short the soil is broken by the sharply folded upper end of this loop, and not long after this the cotyledons are lifted out of the earth and raised to an upright position in the air and sunshine.

The peg above described is found common to all the cultivated species of cucurbitaceous plants investigated. It varies in size and shape, but its important characteristics are much the same. With seeds like the squash it is natural to expect that this appendage would be larger than with the cucumber or the gherkin. As before observed its structure is entirely cellular, that is, no vessels or fibers are formed to give it additional strength and permanence. It evidently has served its purpose when the coats are removed from the seed-leaves, and no indications have been found of any growth of the peg after the cotyledons are free in the air. The hairs quickly die away from the under surface and no instance of any semblance to roots has been observed upon this temporary organ, although roots often start out from the main root close below it.

Extended experiments have been carried on to determine if

possible the most advantageous position of the seed for the action of the peg and the removal of the seed-coats. In all cases where there was sufficient surface moisture to the soil, as when kept damp by being covered by a bell-jar resting on a plate containing water, the seeds germinated quickly, and in every instance the peg did its work perfectly, and in full view of any observer. The hypocotyledonary loop instead of breaking the ground above it, simply lifted itself into the air and drew the cotyledons free from the seed-coats. The latter were held firmly in a horizontal position by the lip; they were literally pegged to the surface of the soil. It is probably true that under the most favorable conditions of soil, moisture and warmth, the seeds of cucurbitaceous plants would germinate the most rapidly when sown flat upon the surface. This is the position which such seeds would naturally take in being scattered upon the soil. There are, however, of course many dangers incident to such an exposure of the seeds, such as graminivorous birds and other animals, etc., and the method however advantageous under ideal circumstances might be far from practicable as conditions naturally exist.

A position with the root end downward was quite favorable for the development of the young stem, but the seed-leaves in many cases came above ground with the coats still inclosing them, and as they had no way of removing these hindrances to growth, such plants either died or became much dwarfed. The worst position of all is that with the root end upward. This is more empatically true if the seeds are not deeply planted. In the experiments the seeds thus placed were the first to make a showing above the ground. The root tip came in sight and aftergrowing into the air it either turned downward and entered the soil or sent out laterals which curved down and obtained a foothold in the earth. The behavior of these unfortunate seeds was both amusing and painful. Seeds placed edgewise in the earth were required to develop very wide pegs that they might catch and hold the edges of both halves of the seed-coats. In some cases the peg failed to do its work and the seed-coats came to the surface adhering to the cotyledons. It is easy to see how such a contrivance would be at a great disadvantage. It must serve as a wedge between the partly spread, vertical halves of the seed-coats, and at the same time be a means of holding back the

coats. This position of the seed is far inferior to that in which one flat face is upward and the other downward. An early removal of the seed coats in a germinating plantlet is of no small consequence especially with seeds so large as those under consideration.

There is a very practical bearing of these experiments upon the work of seed sowing. It is a common practice among gardeners and farmers to prepare the "hills" for the melons, squashes, and other members of the gourd family, and then with thumb and finger thrust the seeds either endwise or edgewise into the soil. Should the seed be placed with the root end uppermost and close to the surface of the soil, there is very little hope of a plant therefrom ever getting a good start. When the reverse is true, and the root end points directly downward, the plantlet experiences great difficulty in developing a peg that will remove the seed coats. It has also been shown that seeds placed edgewise are not in a favorable position for the peg to act. It needs to be very wide, and then only the ends have an opportunity to hold back the vertical edges of the two halves of the seed coat. The conclusion is evident that the best conditions are secured when the seed is placed upon one of its broad faces. This position is the one such seeds would take when left to fall naturally upon a level surface. Therefore, the "hills" could be prepared as in the ordinary way, the seeds sown upon the levelled surface and afterwards covered with the required depth of soil. These conclusions are abundantly sustained by actual tests in the garden.

The results here given appeared in the July number (1887) of *Agricultural Science.*

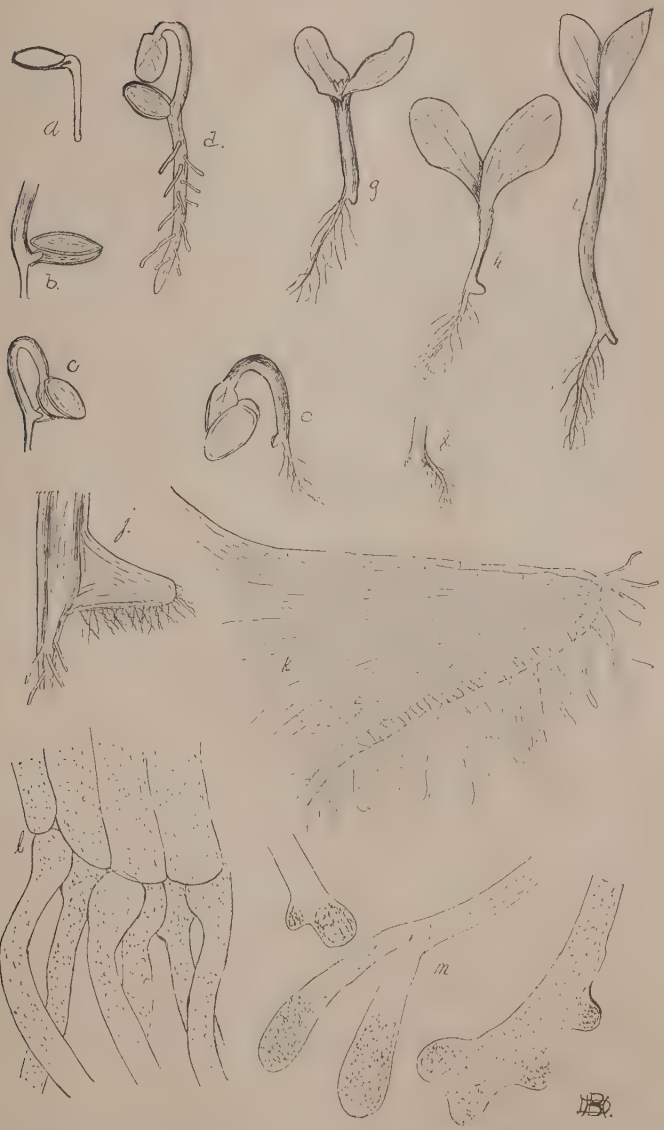

PLATE I.—GERMINATION OF CUCURBITACEOUS PLANTS

EXPLANATION OF PLATE I.

a. The early stage of germination of a nutmeg melon seed, which was lying flatwise upon moist blotting paper.
b. A view of same later with the cotyledons elevated and the coats held by the peg which extends over the point of lower half of seed coat.
c. Indicates how the coats are removed by the peg in seeds lying flatwise.
d. The same kind of seed germinating edge-wise in soil; the two halves of the coats have been held down by the broad peg and the cotyledons are being lifted into position.
e. Shows an edgewise seed from which the peg has slipped from its hold and the cotyledons may become elevated, carrying the seed coats with them.
f. The shape of peg, in front view, when developed between the two halves of a vertical seed-coat; it is broad and strong at the sides, while in horizontal seeds it is thickest in the center and not broad.
g. Shows proportions of Hubbard squash seedling, cotyledons small hypocotyl stout.
h. Same of nest-egg gourd, seed-leaves large and slender short stem.
i. Winter crook-neck squash with long stem and medium sized cotyledons.
j. Enlarged view of a section of peg and stem; the dark portions of latter indicate position of vessels. The peg is entirely cellular tissue.
k. A highly magnified view of section of peg as shown in j.
l. Much more highly enlarged view of a few hairs at their union with the surface cells.
m. Tips of hairs showing protoplasmic matter, branching and nodules for adhering to inner coat of seed.

NITROGEN APPROPRIATION IN CLOVERS: A HINT.

Nitrogen is an essential constituent of protoplasm, and therefore present in all living parts of a plant. Although the atmosphere is a vast store-house of nitrogen, it has not been satisfactorily shown that this free gas is directly available, to any considerable extent, for the growth of crops. The accurate, and long continued field experiments of Messrs. Lawes and Gilbert, indicate that it is soil-nitrogen which plants employ in the processes of their development. In other words, the nitrogen of plants is absorbed by the roots, and enters only to a slight extent elsewhere.

Nitrogen exists in many combinations within the soil. It may be so firmly united with other elements that the compound

is insoluble in the soil water, and therefore the growing plant cannot absorb it. In short, soil-nitrogen is divided, in a general way, into that which is soluble and that which is not. Only the former can serve directly as plant-food, and the latter is of use only as it can be made to change its union with other elements and combine, forming some salt soluble in the soil-water.

It is a matter of general observation that some crops have a much greater power of obtaining nitrogen than others. This fact has led many theorists to believe that some plants possess great power for seizing upon the free nitrogen of the atmosphere. In favor of this theory they have called attention to the greater leaf surface, and the more porous character of the aerial tissues of such plants. On the other hand, the differences have been ascribed to a greater root system, and plants so constructed have been styled "deep feeders," or "wide feeders." This latter view is true to a limited extent, but it does not account for all the differences, and has far from satisfied the minds of the most thorough investigators upon the subject.

Farm crops are somewhat easily divided into two groups, according to their ability to gather nitrogen, namely: the cereals and the leguminous crops. The timothy may be taken as a type of the great family to which cereals belong, and red clover is a fine representative of the order leguminosæ.

It must be borne in mind that a large part of the nitrogen of a naturally rich soil is in the form of organic compounds, which collectively have received the name of humus. This humus, or vegetable mould, is the accumulation of a long term of years, and holds, as under lock and key, a supply of nitrogen, which is gradually yielded to succeeding crops. A soil that has long been under cultivation requires an almost annual supply of nitrogen, and, as this is usually applied in an insoluble form, there must be a rapid change of these compounds into a form ready for entrance into the greedy roots of the growing plants. This process of breaking down of the closely knit organic compounds of nitrogen is now known under the general term—nitrification. This is the keystone in the broad and enduring arch of profitable agriculture. The latest theory of nitrification ascribes the process to the action of small organisms which belong to the group of bacteria. It is assumed that these minute

germs of fermentation and putrefaction are widely distributed through the soil—an assumption, which no one who is at all familiar with these ubiquitous bodies, will doubt for a single instant. The practical importance of the bacteria nitrification is easily recognized, now that their role in the economy of plant nutrition is fairly understood. Professor Storer, in his recent work on "Chemistry in Some of its Relations to Agriculture," referring to the generally accepted theory of nitrification, writes as follows: "Not only will farmers soon learn to make composts, and to apply manures in a more rational manner than was possible before, but they will take pains to foster and protect the ferment germs and sow them, as it were, and cultivate them in fit places."

The different capacities of cereal and leguminous crops for appropriating soil-nitrogen, is well illustrated by a series of experiments carried out by Dr. Kedzie, and summarized in the report of the Society for the Promotion of Agricultural Science for 1886 (page 40). In one case the wheat plant, grown in a mixture of swamp muck and sand, gained 25 fold over the amount of nitrogen in the seed, while a clover plant, under the same conditions, increased its nitrogen 1,068 times. Another year the results for wheat were 116 fold, and for clover 3,892. Under conditions, where all active nitrogen had been removed from the artificial soil, the wheat plant contained only double the amount of nitrogen of the seed, while the clover plant yielded 566 fold of increase.

It was with a shadow of a hope of gaining some light upon the dark subject of the differences in the ability of plants, to appropriate nitrogen, that the microscope has been applied to the roots of typical plants of the two great classes. The two species employed were timothy and red clover. The seeds of these two species were sown together between folds of blotting paper, and kept constantly moist. The clover seeds rapidly absorbed water, and soon swelled to twice their original bulk. The outer coat burst and the root of the plantlet began to rapidly elongate. At the end of three days there was a fine growth of hairs upon the roots an inch behind their tips. These hairs were irregular in outline, somewhat club-shaped, and often twisted around each other into knotty masses. The tip of the clover root is characterized by having a profusion of loose cells,

which are continually being detached from the root surface. They are the exfoliated cells of the root cap, and each contains an abundance of protoplasm, and a well defined nucleus. The contents exude soon after they become detached and form a slimy envelope. As the growing roots push on, this viscid deposit comes in contact with the root surface at a place behind the tip where the epidermal cells are developing into hairs. This slime seems to act as a stimulant to the young hairs which grow rapidly and become most twisted and contorted where the exudation from the exfoliated cells is the most abundant. This exudation quickly became the breeding place of countless bacteria, with all the activities common to any of the ordinary fermenting substances. The microbes thus developed were not of any single species, and ranged in size from 5 μ to one $\frac{1}{100}$th of that small space. Later on, representatives of all groups of bacteria were found, varying from the minute spherical micrococcus to the rods of the genus bacterium and cork-screw shapes of the genus spirillum.

It seems only reasonable to entertain the opinion that the abundant and continuous exfoliation of cells from the root tip furnishes a substance which, in the natural growth of the root, comes in contact with the young root hairs and yields nourishishment to them. At the same time the slime becomes a nidus for the development of bacteria, which in turn perform the function ascribed to them. With young seedlings upon the surface of moist paper there is very little inert nitrogen present for the microbes to work upon, and with all further nourishment, outside of the seed absent, the experiment terminates as a fermented mass in the culture dish.

Clover seeds have also been sown in soil in flower-pots, and the seedlings examined from day to day. The young roots from the soil exhibit the same structure and development as detailed above. The exfoliated cells from the root tips came in contact with the root, an inch or so behind the cap, and the twisted hairs and numerous microbes are their constant attendants, so far as the observations have been made. The soil adheres very closely to the surface of this part of the root, so that it is difficult to see all that may be desired. These patches of earth seemed to have been formed by the slime, and became glued to the root-surface. In

such places bacteria are abundant, and it is here that the greater part of the absorption of food takes place by the roots. If the bacteria can assist in the work of nitrification, it is true that they are most abundant in places where they do the most good.

With the timothy the germination is very different from that of the clover. A sheath is first produced, upon which long hairs grow, and serve to anchor the grain to the object of support. The first root is much more slender than that of the clover, and has fewer hairs, which are finer, and without any tendency to twist into braids or form knots. The root tip has an occasional free cell peeling from the surface of the cap, and only these are without the abundance of slime seen in the clover. In short, the timothy root, whether on the moist blotting paper or growing in the soil, has a straight forward, clean and dignified habit, quite unlike that of the clover. In one case it was observed that the tip of a timothy leaf came against a clover root at nearly right-angles. All the clover root-hairs bent toward the timothy leaf and applied their tips to its surface. Many other hairs, unable to reach the leaf, had bent toward it, and were resting upon their more fortunate neighbors. There was a strong suspicion of parasitism, but the greedy clover is not charged with this tendency upon so incomplete evidence.

It has been shown that there are wide structural differences between the red clover and timothy as seedling plants. With older representations of the species there are even more root distinctions. It has long been known that many of the leguminous plants possess small enlargements upon the roots. These outgrowths, sometimes called tubercles or galls, have been the subject of no little speculation and even controversy. Their presence has been ascribed to insects and fungi; but whatever their origin, it is generally believed that they are no detriment to the infested plant. Their shape and size are quite constant for the same species. Upon the roots of the red clover they are ovate, and about one-twentieth of an inch in length. In the yellow clover (Trifolium procumbens, L.) they are three times as long as broad, and twice the length of those of the red clover. Those of the alsike clover are pear-shaped, and four times the size of those of the red clover, while in the melilot (Melilotus officinalis, Willd.) they are an eighth of an inch long, grouped in close clusters an inch or more in diameter. These galls all agree in general structure. There

is a thin outer layer of dark, thick-walled cells, beneath which is a tissue, consisting of long cells with thin walls. Rudimentary fibro-vascular bundles are scattered here and there. The central portion of each gall is made up of large oval cells, loosely packed together, and with brownish contents. When the section is viewed with the higher powers of the microscope, the central cells are seen to possess a large brown nucleus, and many motile bodies of extreme minuteness, which are very active within the cell wall. The surrounding liquid upon the glass slide was also filled with the same small bodies. Tubercles of nearly full size were found upon seedling plants not over six weeks old growing in a rich soil. In these the central cells were crowded with the small motile bodies, and the brown nucleus was less evident. The minute particles are colored brown by iodine, which slowly arrests their movements. When methyl green in acetic acid is added to a fresh section of the tubercle, the motion of the particles within the cells and without is almost instantly arrested. The tubercles have not been found upon plants before the first true leaves have developed, but with plants not over a month old, and having only a main root four inches long, and a few short side roots, as many as ten developing tubercles were found.

It seems reasonable to conclude that the motile bodies within the tissues of the tubercles are bacteria, and similar, if not identical, with the microbes infesting the slime formed from the exfoliating cells of the root cap. It may also be true that the tubercles upon the roots of the clovers and allied plants are enlargements, furnishing favorable conditions for the rapid development of bacteria. These microbes, when finding their way into the soil-water surrounding the growing plant, may aid in the decomposition of the insoluble compounds of nitrogen, and prepare them for entrance into the absorbing roots.

It is possible that we have here a key that unlocks one of the secret chambers of plant nutrition. The clovers and related leguminous crops, it appears, are especially provided with means of inducing nitrification, while the grasses and cereals are not. It may be that "clover sickness," and a host of kindred unsolved problems connected with "root residues," will be no less obscure in the light of the above investigations.

The results of the above experiments recently appeared in the last report of the Society for the Promotion of Agricultural Science.

PRELIMINARY LIST OF THE WEEDS OF IOWA.

The plants herein enumerated, either frequently or always, occupy the land to the exclusion of more useful species and are therefore known as weeds. It is often difficult to decide whether a certain species should go into this preliminary list and therefore some are included which are not much more destructive or annoying than many others that have been omitted. The list is made quite inclusive and some members may perhaps be dropped when their habits are better known. If any species, not herein mentioned, is a decided pest in the State, it is desired that it be reported and the list become as complete as possible. It would greatly increase the value of this paper if localities could have been given under each species, but this at present is not possible. It is, however, hoped that the range of our worst weeds, at least, may be determined and prevented in the near future.

Weeds are divided into two classes, whether native, or introduced from other countries. This distinction is shown by the foreign members being printed in *Italics* while our own species are set in **full face type**. Thus, **Ranunculus repens**, L. is a native while *Ranunculus bulbosus*, L. is from abroad. The species are again divided into three groups. The first includes those which are universally known as aggressive weeds. These not only hold what land they secure, but make a strong fight for the possession of new territory. This hostile character is indicated by the numeral one in the parenthesis (1) following the common name of the species. The second group includes plants which are less annoying to the farmer and gardener but have a weedy habit and are rarely of service for forage or other purposes. Thus *Sisymbrium officinale*, Scop., hedge mustard, (2), is a foreign species of this group which inhabits wet places and often covers low areas with a comparatively worthless herbage, but rarely excludes more valuable plants on higher and drier ground. In this it is quite different from its near relative the ubiquitous Shepherd's purse which ranks among the first class (1) as a troublesome pest in the most valuable soil of the garden. In the third class (3) is placed a host of plants many of which are of a negative character,—they are neither good nor very bad, of little

value and will usually succumb easily under the conditions of ordinary culture. In the region covered by this list they are in large part prairie plants which will yield their place to the breaking plow, the mowing machine or to close pasturage. The Mandrake (**Podophyllum peltatum**, L.) may be taken as an average native species of this class, while next to it in the list is *Chelodonium majus*, L. celandine (3) an introduced species of the same group. Both grow in moist shady places and may cover considerable areas with an unprofitable herbage but never encroach upon a cultivated field.

The words following the number indicate, in a general way the place where the plant most frequently abounds and the capital letter at the end shows whether the species is an annual (A), a biennial (B), or a perennial (P). Some of the so-called biennial plants may be either annuals or perennials according to circumstances. Some of the A's and P's may also vary and therefore the index of longevity is given with limitations.

The reader will at once appreciate the difficulty connected with placing many of the species in one of the three groups. Frequently the plant is almost upon the line, and further knowledge will doubtless change its position. Bear in mind, however, that the list is for one State and that many of the worst weeds in the Eastern States or other parts of the United States are few in numbers here and outdone in their mischief-making by other plant pests. On this basis the ox-eye daisy or bull's-eye (No. 142) is placed in the second class while in New York it has almost ruined pastures and meadows in many parts of the State. If the list was for the whole country this daisy would doubtless be among the first ten of the first list. With us, however, the intruder does not make its accustomed headway in grass land and this in part is due to a lack in the seed-formation—a fortunate tendency to abort, favorable to the farmers of the West.

The list is arranged by families according to the classification of the orders in Gray's Manual. This brings near each other all species that are closely related. Any other plan is quite sure to widely separate the members of the same genus and the arrangement becomes entirely artificial. Especial effort has been made to obtain the common names of the various kinds of weeds

and they are brought together as synonyms following the scientific name. This double name, which is the only reliable basis for classification because it rests upon a full, recorded botanical description, has been placed first because it is the compound term by which the species is known to all scientific students of plants in all languages and parts of the world. A common name at best arises by common consent and bears with it all the possibilities of confusion attached to such undefined terms. For example "none-such" to one may be "medick" to another and "medicago" to others. "Daisy" is a general term applied to a score of species. The plant called "fireweed" in one section may be known only as "wild lettuce" in another. Vipers bugloss has several other names, and this is true of dozens of weeds if not of nearly all, if the whole history of field and garden nomenclature and folk-lore on the subject were known. On account of the confusion incident to the growth of common terms applied to common plants it is hoped that any names of weeds not in the alphabetical list will be sent for addition thereto. There are doubtless many local names which should be secured. A portion of the plant itself should accompany the term that the latter may find its proper place in the classified list of species where it will become an added synonym.

In the alphabetical index of common names reference is made by number to the species with which it has been associated or to which it is locally or occasionally applied.

PRELIMINARY LIST OF IOWA WEEDS.

RANUNCULACEÆ, CROWFOOT FAMILY.

1. **Anemone dichotoma** L.—Pennsylvania wind flower (3) neglected grass land (**P.**)
2. **Thalictrum dioicum** L.—early meadow rue, (3) meadows and pastures. (**P.**)
3. **Thalictrum polygamum.** MUHL.—tall meadow rue, (3), wet meadows. (**P**).
4. **Thalictrum purpurascens,** L - purple meadow rue, (3), wet meadows, (**P**).
5. **Ranunculus abortivus,** L –small flowered buttercup, (3), wet ground, (**P**).
6. **Ranunculus repens,** L –creeping buttercup, (3) wet meadows, (**P**).
7. *Ranunculus bulbosus,* L—bulbous buttercup, (2), pastures, (**P**).
8. *Ranunculus acris,* L –tall crowfoot, buttercup, (2), pastures, (**P**).

9. **Delphinium azureum,** MICHX—azure larkspur, (3), upland meadows, (P).

BERBERIDACEÆ, BARBERRY FAMILY.

10. **Podophyllum peltatum,** L—mandrake, may-apple, hog-apple, (3), woodland pastures, (P).

PAPAVERACEÆ, POPPY FAMILY.

11. *Chelidonium majus,* L—celandine, (3), moist waste ground, (P).

CRUCIFERÆ, MUSTARD FAMILY.

12. **Nasturtium palustre,** D C.—marsh-cress, (3), wet places, (B).
13. *Nasturtium Armoracia,* FRIES—horse-radish, (3), neglected gardens, (P).
14. **Hesperis matronalis,** L—dame rocket, (3), rich waste ground, (P).
15. *Brassica alba* BOIS, L—white mustard, (2), neglected soil, (A).
16. *Brassica nigra,* BOIS, L—black mustard, (2), neglected soil, (A).
17. *Brassica Sinapistrum,* BOIS, L—charlock, yellow mustard, (1), grain and stubble fields, (A).
18. **Barbarea vulgaris,** R. BR.—yellow rocket, (3), waste moist places, (B).
19. *Sisymbrium officinale,* SCOP—hedge mustard, (2), moist places, (A).
20. *Camelina sativa,* CRANTZ—false flax, (3), cultivated fields, (B).
21. *Capsella Bursa-pastoris,* MŒNCH—shepherd's purse, (1), cultivated and waste ground, (A).
22. **Lepidium Virginicum,** L—pepper grass, (2), neglected ground, (A).

CAPPARIDACEÆ, CAPER FAMILY.

23. **Polansia graveolens,** RAF—Polansia, (3), dry sandy shores, (A).

VIOLACEÆ, VIOLET FAMILY.

24. **Viola palmata var. cucullata,** GRAY—blue violet, (3), moist places, (P).

HYPERICACEÆ, ST. JOHN'S WORT FAMILY.

25. *Hypericum perforatum,* L.—St. John's wort, (3), meadows and pastures, (P).

CARYOPHYLLACEÆ—PINK FAMILY.

26. *Saponaria officinalis,* L.—bouncing bet, (2), waste ground, (P).
27. *Vaccaria vulgaris,* HOST—cow herb, (2) waste places, (A).
28. *Silena inflata,* SMITH—bladder campion, (3), waste ground (P).
29. *Lychnis Githago,* LAM—corn cockle (1), grain fiields, (A).
30. *Lychnis vespertina,* SIBTH—evening lychnis, cockle, (2), waste ground, (B).
31. *Arenaria serpyllifolia,* L—thyme leaved sand wort, (3), waste sandy soil, (A).
32. *Stellaria media,* SMITH—chickweed, (1), shady moist ground, (A).
33. **Stellaria longifolia,** MUHL—stitch wort, (3), pastures, (P).
34. *Cerastium viscosum,* L—mouse-ear chickweed, (2), open fields, (P).

35. *Spergula arvensis*, L—corn spurrey, (1), grain fields, (A).

PORTULACACEÆ, PURSLANE FAMILY.

36. *Portulaca oleracea*, L—purslane, pusley, (1), cultivated gardens (A).

MALVACEÆ, MALLOW FAMILY.

37. *Malva rotundifolia*, L.—round leaved mallow, cheeses, (2), waste shady ground, (P).
38. Callirrhœ involucrata, GRAY—callirrhoe, (1), moist grass land, (P).
39. *Sida spinosa*, L.—sida, (2), neglected ground, (A).
40. *Abutelon Avicennæ*, GÆRT —velvet leaf, butter-print, (1), cultivated soil, (A).
41. *Hibiscus Trionum*, L.—bladder ketmia, (2), cultivated ground, (A).

LINACEÆ, FLAX FAMILY.

42. Linum sulcatum, RIDDELL—wild flax, (3), dry meadows, (A).

GERANIACEÆ, GERANIUM FAMILY.

43. Geranium maculatum, L.—spotted cranesbill, (3), dry grass land, (P).
44. Impatiens palida, NUTT—pale touch-me-not, (3), wet places, (A).
45. Impatiens fulva, NUTT—spotted touch-me-not, (3), wet places, (A).
46. Oxalis violacea, L—violet wood sorrel, (3), grass land, (P).
47. Oxalis corniculata var. stricta, SAV.—yellow wood sorrel, (3) grass land, (P).

ANACARDIACEÆ, CASHEW FAMILY.

48. Rhus Toxicodendron, L.—poison ivy, poison oak, (2), moist shady places, (P).
49. Rhus glabra, L.—smooth sumac, (3), neglected ground, (P).

RHAMNACEÆ, BUCKTHORN FAMILY.

50. Ceanothus Americanus, L—New Jersey tea, red root, (3), dry pastures, (P).

LEGUMINOSÆ, PULSE FAMILY.

51. Crotalaria sagittalis, L—rattle-box, (2), pastures, (A).
52. Trifolium repens, L—white clover, (3), cultivated ground, (P).
53. *Trifolium procumbens*, L—low hop clover, (2), cultivated ground, (A).
54. *Trifolium arvense*, L—rabbits foot clover, (2), poor soil, (A).
55. Trifolium agrarium, L—yellow hop clover, (2), cultivated ground, (A).
56. *Melilotus officinalis*, WILLD—melilot, yellow sweet clover, (3), neglected ground, (B).
57. *Medicago lupulina*, L—nonesuch, black medick, medicago, (3,) neglected ground, (B).
58. *Medicago sativa*, L—lucerne, alfalfa, (3), neglected ground, (P).
59. Amorpha canescens, NUTT—lead-plant, (3), grass land, (P).
60. Astragalus caryocarpus, KER—ground plum, (3), grass land, (P).
61. Astragalus Canadensis, L—milk-vetch, (3), grass land, (P).

62. **Oxytropus Lamberti**, PURSH—loco, oxytropus, (3), grass land, (P).
63. **Vicia Americana**, MUHL—vetch, (3), grass land, (P).
64. **Baptisia leucophæa**, NUTT—yellow false indigo, (3), grass land, (P).
65. **Lespedeza violacea**, PERS—bush clover, (3), grass land, (P).

ROSACEÆ, ROSE FAMILY.

66. **Rosa blanda**, AIT—early wild rose, (2), grass land, (P).
67. **Agrimonia Eupatoria**, L—common agrimony, (3), shady places, (P).
68. **Geum album**, GMEL—white avens, (3), shady places, (P).
69. **Potentilla Norvegica**, L—Norway cinquefoil, five-finger, (3), waste places, (B).
70. **Potentilla Canadensis**, L—cinquefoil, slender five-finger, (3), grass land, (P).
71. **Rubus strigosus**, MICHX—wild red, raspberry, (3), waste places, (P).
72. **Rubus villosus**, AIT—high blackberry, (3), waste places, (P).
73. **Rubus occidentalis**, L—black-cap, thimble berry (3), waste places, (P).

SAXIFRAGACEÆ, SAXIFRAGE FAMILY.

74. **Heuchera hispida**, PURSH—alum root, (3), waste places, (P).

CRASSULACEÆ, ORPINE FAMILY.

75. **Penthorum sedoides**, L—ditch stone crop, (3), wet places, (P).

ONAGRACEÆ, EVENING PRIMROSE FAMILY.

76. **Epilobium augustifolium**, L—great willow herb, fire weed, (3), cleared land, (R).
77. **Epilobium coloratum**, MUHL—smaller willow herb, (3), wet places, (P).
78. **Œnothera biennis**, L—common evening primrose, (1), grass land, (B).
79. **Ludwigia polycarpa**, S. AND P—false loosestrife, (3), wet places, (P).

CACTACEÆ, CACTUS FAMILY.

80. **Opuntia Rafinesquii**, ENGL—prickly pear, Indian fig, (3), dry grass land, (P).
81. **Opuntia fragilis**, HAW—prickly pear, (3), dry grass land, (P).

CUCURBITACEÆ, GOURD FAMILY.

82. **Sicyos angulatus**, L—star cucumber, (3), low ground, (A).
83. **Echinocystis lobata**, T. AND G—balsam apple, wild cucumber, (2), moist cultivated ground, (A).

UMBELLIFERÆ, PARSLEY FAMILY.

84. **Eryngium yuccæfolium**, MICHX—button snake root, (3), dry grass land, (P).
85. *Daucus Carota*, L—carrot, (1), meadows and pastures, (B).
86. **Heracleum lanatum**, MICHX—cow parsnip, master wort, (2), moist places, (P).
87. *Peucedanum sativum* L.—parsnip, (1), grass land (B).
88. **Thaspium aureum**, NUTT—meadow parsnip, (3), moist land, (P).

89. **Cicuta maculata,** L.—water hemlock, (3), wet places, (P).
90. **Cryptotænia Canadensis,** D C.—honewort, (3), moist shady places, (P).
91. *Conium maculatum,* L.—poison hemlock, (3), moist ground, (B).
92. **Archemora rigida var. ambigua,** T. AND G.—cowbane, (3), wet places, (P).

CAPRIFOLIACEÆ, HONEY-SUCKLE FAMILY.

93. **Sambucus Canadensis,** L.—elderberry, (3), neglected ground, (P).

COMPOSITÆ, SUNFLOWER FAMILY.

94. **Vernonia fasciculata,** MICHX.—iron weed, (1), low pastures, (P).
95. **Vernonia Noveboracensis,** WILLD—iron weed, (1), low pastures, (P).
96. **Liatris pycnostachya,** MICHX—blazing star, (3), moist meadows, (P).
97. **Kuhnia eupatorioides,** L.—kuhnia, (2), dry pastures, (P).
98. **Eupatorium purpureum,** L.—trumpet-weed, joe-pye weed, (2), low land, (P).
99. **Eupatorium perfoliatum,** L.—boneset, thoroughwort, (2), low ground, (P).
100. **Aster Novæ Angliæ,** L.—New England aster, (3), moist ground (P).
101. **Aster ericoides,** L.—heath-like aster, (3), poor soil, (P).
102. **Aster miser,** L.—starved aster, (3), poor soil, (P).
103. **Aster cordifolia,** L.—heart-leaved aster, (3), shady places, (P).
104. **Aster patens,** AIT—spreading aster, (3), dry ground, (P).
105. **Aster, (Diplopappus) umbellatus,** WILLD—umbellate aster, (3), moist ground, (P).
106. **Aster amethystinus,** NUTT—amethyst aster, (3), dry ground, (P).
107. **Erigeron Canadensis,** L.—horse weed, fleabane, colts tail, (1), waste ground, (B).
108. **Erigeron annuus,** PERS—daisy fleabane, sweet scabious, (1), neglected ground, (A).
109. **Erigeron Philadelphicus,** L.—common fleabane, (2), moist places, (P).
110. **Erigeron strigosus,** MUHL—rough-stemmed fleabane, (2), dry ground, (B).
111. **Erigeron bellidifolius,** MUHL—robin's plantain, (3), wet places, (P).
112. **Solidago Canadensis,** L. Canada golden rod, (3), grass land, (P).
113. **Solidago serotina,** AIT—late golden rod, (3), grass land, (P).
114. **Solidago rigida,** L.—stiff golden rod, (3), dry places, (P).
115. **Solidago Missouriensis,** NUTT—Missouri golden rod (3), dry places, (P).
116. **Silphium laciniatum,** L.—compass plant, rosin weed, (3), dry places, (P).
117. **Silphium perfoliatum,** L.—cup plant, (3), moist places, (P).
118. **Ambrosia trifida,** L.—horse weed, great ragweed, (1), neglected ground, (A).

119.—**Ambrosia artemesiæfolia**, L.—ragweed, Roman wormwood, hogweed, bitter weed, (1), neglected ground, (A).
120. **Xanthium Canadense**, MILL. —clot bur, cockle bur, (1), neglected ground, (A).
121. **Heliopsis lævis**, PERS.—ox-eye, (3), low ground, (P)
122. **Echinacea purpurea**, MŒNCH—purple cone flower, (2), dry grass land, (P).
123. **Echinacea augustifolia**, D C.—long-leaved, purple cone flower, (2), dry grass land, (P).
124. **Rudbeckia laciniata**, L.—cut-leaved coneflower, (2), shady places, (P).
125. **Rudbeckia hirta**, L.—yellow daisy or cone-flower, (2), grass land, (P).
126. **Rudbeckia subtomentosa**, PURSH—hairy cone flower, (2), dry places, (P).
127. **Lepachys pinnata**, T. AND G.—pinnate cone flower, (2), dry places, (P).
128. *Helianthus annuus*, L.—common sunflower, (1), cultivated ground, (P).
129. **Helianthus rigidus**, DESF—stiff sunflower, (2), dry places, (P).
130. **Helianthus grosse-serratus**, MART—saw-toothed sunflower, (2), dry places, (P).
131. **Helianthus strumosus**, L.—tuberous sunflower, (2), low places, (P).
132. **Helianthus doronicoides**, LAM.—arnica sunflower, (2), low places, (P).
133. **Actinomeris squarrosa**, NUTT.—actinomeris,(2), moist pastures,(P).
134. **Bidens frondosa**, L.—bur marigold, stick seed, pitchforks, beggar-sticks, (1), neglected ground, (A).
135. **Bidens chrysanthemoides**, MICHX.—large beggars ticks, bur marigold, (2), moist places, (A).
136. **Bidens connata**, MUHL.—swamp beggars ticks, marigold, (2), moist places, (A).
137. **Bidens cernua**, L.—small beggars ticks, bur marigold, (2), wet ground, (A).
138. **Helenium autumnale**, L.—sneeze weed, (2), moist ground, (P).
139. *Anthemis Cotula* L.—may weed, dog fennel,(1), waste places, (A).
140. *Anthemis arvensis*, L.—corn chamomile, (3), waste places, (A).
141. **Achillea millefolium**, L. —milfoil, yarrow, (2), grass land, (P).
142. *Chrysanthemum Leucanthemum*, L.—ox-eye daisy, bull's-eye, (2), grass land, (P).
143. *Tanacetum vulgare*, L. —tansy, (2), neglected places, (P).
144. **Artemesia serrata**, NUTT. —serrate leaved wormwood, (3,) grass-land, (P).
145. **Artemesia frigida**, WILLD.—silvery wormwood,(3), grass land,(P).
146. **Artemesia biennis**, WILLD.—biennial wormwood,(3),dry places,(B).
147. *Artemesia annua*, L.—annual wormwood, (3), dry places, (A).
148. **Artemesia Ludoviciana**, NUTT. -wormwood, western mugwort, (3), dry places, (P).

149. **Artemesia dracunculoides,** PURSH—large wormwood, (3), dry places, (P).
150. **Gnaphalium polycephalum,** MICHX.—cudweed, everlasting, (3), dry places, (P).
151. **Antennaria plantaginifolia,** HOOK.—plantain-leaved everlasting, (3), dry places, (P).
152. **Erechthites hieracifolia,** RAF. fireweed, (3), neglected land, (A).
153. **Senecio aureus,** L.—groundsel, golden rag-weed, squaw-weed, (3), moist ground, (P).
154. *Cnicus arvensis,* HOFFM.—Canada thistle, (1), cultivated soil, (P).
155. **Cnicus lanceolatus,** HOFFM.—bull-thistle, pasture thistle, (1), grass land, (P).
156. **Cnicus altissimus,** WILLD.—common thistle, (1), grass land, (P).
157. **Cnicus altissimus var. discolor,** GRAY -common thistle (1), grass land, (P).
158. **Cnicus pumilus,** TORR.—pasture thistle, (1), grass land, (P).
159. *Arctium Lappa,* L.—burdock, (1), neglected ground, (P.)
160. *Cichorium Intybus,* L.—cichory, succory, (2), neglected ground, (P).
161. **Hieracium scabrum,** MICHX. -rough hawk-weed, (3), shady places, (P).
162. **Hieracium longipilum,** TORR -long haired hawk-weed, (3), grass land, (P).
163. **Hieracium venosum,** L.—rattle snake weed, (3), dry places, (P).
164. **Hieracium Canadense,** MICHX.—Canada hawk-weed, (3), dry places, (P).
165. **Prenanthes (Nabulus) alba,** L.—white lettuce, (2), dry places, (P).
166. **Prenanthes racemosa,** MICHX.—rattle snake root, (2), moist places, (P).
167. **Prenanthes aspera,** MICHX.—rattle snake root, (2), dry places, (P).
168. *Taraxacum officinale,* WEBER—dandelion, (1), grass land, (P).
169. **Lactuca pulchella,** D C.—beautiful wild lettuce, (3), waste land, (P),
170. **Lactuca Canadensis,** L.—wild lettuce, trumpet weed, fire weed, (2), neglected ground, (B).
171. **Lactuca leucophæa,** D C. -blue lettuce, (2), neglected ground, (B).
172. *Sonchus oleraceus,* L.—sow-thistle, (2), neglected ground, (A).
173. *Sonchus asper,* VILL.—spiny-leaved sow-thistle, (2), neglected ground, (A).

LOBELIACEÆ, LOBELIA FAMILY.

174. **Lobelia syphilitica,** L.—great blue lobelia, (3), moist places, (P).

CAMPANULACEÆ, CAMPANULA FAMILY.

175. **Specularia perfoliata,** A. D C.—venus looking-glass, (3), waste ground, (A).

PLANTAGINACEÆ, PLANTAIN FAMILY.

176. **Plantago Rugelli,** DECAISNE—native plantain, (3), waste places, (P).
177. *Plantago major,* L.—common plantain, (2), moist waste places, (P).

178. *Plantago lanceolata*, L.—rib-grass, ripple-grass, English plantain, (1), grass land, (P).

PRIMULACEÆ, PRIMROSE FAMILY.

179. *Anagallis arvensis*, L.—common pimpernel, poor man's weather glass, (3), waste places, (A).

SCROPULHARIACEÆ, FIGWORT FAMILY.

180. *Verbascum Thapsus*, L.—mullein, (2), neglected land, (B).
181. *Verbascum Blattaria*, L.—moth-mullein, (2), neglected land, (B).
182. *Linaria vulgaris*, MILLER—butter and eggs, ramsted, toad-flax, (1), grass land, (P).
183. **Scrophularia nodosa**, L.—fig-wort, (3), moist places, (P).
184. **Veronica Virginica**, L.—speedwell culver's root, culver's physic, (3), moist places, (P).
185. **Veronica peregrina**, L. neck weed, purslane speedwell, (2), neglected ground, (A).
186. **Veronica arvensis**, L.—corn speedwell, (2), neglected ground, (B).
187. **Pedicularis Canadensis**, L.—louse-wort, (3), most places, (P).

VERBENACEÆ, VERVAIN FAMILY.

188. **Verbena hastata**, L.—blue vervain, (3), grass land, (P).
189. **Verbena urticifolia**, L. -nettle-leaved vervain, (3), grass land, (P).
190. **Verbena stricta**, VENT.—hoary vervain, (3), grass land (P).
191. **Verbena bracteosa**, MICHX—prostrate vervain, (3), neglected ground, (P).

LABIATÆ, MINT FAMILY.

192. **Teucrium Canadense**, L.—germander, wood sage, (3), moist places, (P).
193. *Mentha piperita*, L.—peppermint, (3), moist places, (P).
194. *Mentha viridis*, L.—spearmint, (3), moist places, (P).
195. **Mentha Canadensis**, L. -wild mint, (3), moist places, (P).
196. **Lycopus sinuatus**, ELL. water hore-hound, (3), moist places, (P).
197. **Pycnanthemum lanceolatum**, PURSH—mountain mint, (3), dry places, (P).
198. **Monarda fistulosa**, L.—wild bergamot, (3), dry places, (P).
199. *Nepeta Cataria*, L.—catnip, (2), waste places, (P).
200. *Nepeta Glechoma*, BENTH. ground ivy, gill, (3), waste places, (P).
201. **Brunella vulgaris**, L. -heal-all, self-heal, blue-curls, (3), grass land, (P)
202. **Stachys aspera**, MICHX. -hedge nettle (2), moist places, (P).
203. *Leonurus Cardiaca*, L.—mother wort, (2), waste places, (P).
204. *Lamium amplexicaule*, L.—dead-nettle hen-bit, (2), waste places, (B).

BORRAGINACEÆ, BORAGE FAMILY.

205. **Echinum vulgare**, L.—vipers bugloss, blue-devils, blue-weed, (1,) waste ground, (B).

206. **Onosmodium Carolinianum,** D C.—false gromwell, (3), dry places, (**P**).
207. *Lithospermum arvense,* L.—field gromwell, stone-weed, wheat-thief, pigeon-weed, (2), grain field, (**B**).
208. **Lithospermum angustifolium,** MICHX.—gromwell puccoon, (3), dry places, (**P**).
209. **Lithospermum canescens,** LEHM.—gromwell, puccoon, (3), dry places, (**P**).
210. **Echinospermum Redowskii, var occidentalis,** WATSON stickseed, (3), waste ground, (**B**).
211. *Echinospermum Lappula,* LEHM. narrow-leaved stickweed, (2), waste ground, (**B**).
212. *Cynoglossum officinale,* L.- hound's tongue, (1), shady places, (**B**).
213. **Cynoglossum Morisoni,** D C. -beggars lice, (2), waste places, (**B**).

HYDROPHYLLACEÆ, WATERLEAF FAMILY.

214. **Hydrophyllum Virginicum,** L. -Virginia water leaf; (3), moist places, (**P**).
215. **Hydrophyllum appendiculatum,** MICHX. water leaf, (3), moist places, (**P**).
216. **Ellesia nyctelea,** L.—ellesia, (3), moist places, (**A**).

CONVOLVULACEÆ, CONVOLVULOUS FAMILY.

217. **Convolvulous sepium,** L. -bracked bind weed, Rutland beauty, (1), neglected ground, (**P**).
218. **Cuscuta glomerata,** CHOISY glomerate dodder, (3), on plants, (**A**).
219. **Cuscuta inflexa,** ENGLM.—dodder, (3), on plants, (**A**).
220. **Cuscuta Gronovii,** WILLD.—dodder, (3), on plants, (**A**).
221. **Cuscuta tenuiflora,** ENGL.—slender flowered dodder,(3), on plants, (**A**).

SOLANACEÆ, NIGHT SHADE FAMILY.

222. *Solanum Dulcamara,* L.—bitter-sweet, (3), waste places, (**P**).
223. *Solanum nigrum,* L.—night shade, (2), waste places, (**A**).
224. **Solanum Carolinense,** L.—horse-nettle, (1), cultivated ground, (**A**)
225. **Solanum rostratum,** DUNAL—beaked horse-nettle, (1), cultivated ground, (**A**).
226. **Physalis viscosa,** L.—viscous ground-cherry, (2), neglected land, (**P**).
227. **Physalis lanceolata,** MICHX.—lance-leaved ground-cherry, (2), neglected land, (**P**).
228. **Physalis pubescens,** L.—hairy ground-cherry, (2), neglected land. (**A**).
229. *Lycium vulgare,* DUNAL -matrimony vine, box thorn, bastard jasmine, (3), waste places, (**P**).
230. *Datura Stramonium,* L. -stramonium, Jamestown weed, Jimson weed, thorn apple, (1), neglected ground, (**A**).
231. *Datura Tatula,* L —purple thorn apple, (1), neglected ground,(**A**).

APOCYNACEÆ, DOGBANE FAMILY.

232. **Apocynum androsæmifolium,** L.—spreading dogbane,(3), moist places,(P).
233. **Apocynum cannabinum,** L. dog bane, Indian hemp, (3), moist places, (P).

ASCLEPEADACEÆ, MILK WEED FAMILY.

234. **Asclepias Cornuti,** DECAISNE milkweed, silkweed, (1), neglected ground, (P).
235. **Asclepias tuberosa,** L.—tuberous rooted milkweed, (3), neglected ground, (P).
236. **Asclepias verticillata,** L.—whorled milkweed, (3), dry ground,(P)
237. **Acerates longifola,** ELL. green milkweed, (3), moist places, (P).

NYCTAGINACEÆ, FOUR-O'CLOCK FAMILY.

238. **Oxybaphus nyctagineus,** SWEET oxybaphus four-o'clock, (3), waste places, (P).

PHYTOLACCACEÆ, POKEWEED FAMILY.

239. **Phytolacca decandra,** L. poke root, scoke, garget, pigeon berry, (2), waste places, (A).

CHENOPODIACEÆ, GOOSEFOOT FAMILY.

240. *Chenopodium album,* L.—lamb's quarters, goosefoot, pigweed, (1), waste ground, (A).
241. *Chenopodium Boscianum,* MOQ.—slender lamb's quarters, goosefoot, (2), waste places, (A).
242. *Chenopodium urbicum,* L.—pale lamb's quarters, goosefoot, (2), waste places, (A).

AMARANTACEÆ, AMARANTH FAMILY.

243. *Amarantus retroflexus,* L.—common pigweed amaranth, (1), neglected ground, (A).
244. *Amarantus albus,* L.—tumbleweed, pigweed (1),neglected ground, (A).
245. **Amarantus Blitoides,** WATSON—prostrate amaranth, (1), waste ground, (A).

POLYGONACEÆ, BUCKWHEAT FAMILY.

246. **Polygonum aviculare,** L. knot grass, doorweed, goosegrass, (1), neglecteded ground, (A).
247. **Polygonum erectum,** L. erect knot grass, (2), neglected ground, (A).
248. **Polygonum hydropiper,** L. smartweed, water peper. (2), moist places, (A).
249. **Polygonum hydropiperoides,** MICHX.—mild water pepper,(2), moist places, (P).
250. *Polygonum convolvulus,* L.—black bindweed, (3), waste places, (A).

251. **Polygonum dumetorum**, L.—climbing false buckwheat, (2), neglected ground, (P).
252. *Polygonum Persicaria*, L.—Lady's thumb, spotted knotweed,(2), waste places, (A).
253. **Polygonum Pennsylvanicum**, L.—Pennsylvania smartweed, (3), moist places, (A).
254. **Polygonum incarnatum**, ELL.—flesh colored smartweed, (3), moist places, (A).
255. **Polygonum amphibium**, var terrestre, WILLD.—water smartweed, (2), moist places, (P).
256. *Polygonum Fagopyrum*, L.—buckwheat, (3), neglected ground, (A).
257. *Rumux crispus*, L.—curled dock, (1) moist places, (P).
258. *Rumex Ascetosella*, L.- field or sheep sorrel, (1), poor soil, (P).
259. **Rumex Britannica**, L.—pale dock, (2), moist places, (P).
260 *Rnmex obtusifolius*, L.—bitter dock, broad-leaved dock, (2), neglected land, (P).

EUPHORBIACEÆ, SPURGE FAMILY.

261. **Euphorbia maculata**, L.—milk purslane, spotted spurge, (2), neglected ground. (A).
262. **Euphorbia hypericifolia**, L.—hypericum spurge, (2), neglected ground, (A).
263. **Euphorbia corollata**, L.—showy spurge, (2), neglected ground,(A).
264. *Euphorbia Cyparissias*, L.—cypress spurge, (3), neglected ground, (A).
265. **Acalypha Virginica**, L.—three-seeded mercury, (2), moist places, (P).

URTICACEÆ, NETTLE FAMILY.

266. **Urtica gracilis**, AIT.—slender nettle, (3), moist places, (P).
267. **Laportea Canadensis**, GAUD.—wood nettle, (3), moist places, (P).
268. **Pilea pumila**, GRAY—rich weed, clear weed, (3), moist places,(P).
269. *Cannabis sativa*, L.—hemp, (3), waste places, (A).

ARACEÆ, ARUM FAMILY.

270. **Arisæma triphyllum**, TORR.—Indian turnip, (3), wet places, (P).
271. **Symplocarpus fœtidus**, SALISB. skunk cabbage, (3), wet places, (P).

TYPHACEÆ, CAT-TAIL FAMILY.

272. **Typha latifolia**, L.—cat-tail, reed mace, (3), wet places, (P).

ALISMACEÆ, WATER PLANTAIN FAMILY.

273. **Sagittaria variabilis**, ENGLM.—arrow head, (3), wet place, (P).

LILACEÆ, LILY FAMILY.

274. **Veratrum Woodii**, ROBBINS.—hellebore, (3), shady place, (P).
275. *Asparagus officinale*, L.—asparagus, (3), neglected ground, (P).
276. **Allium Candaense**, KALM.—wild garlic, (3), moist places, (P).

277. **Allium cernuum**, ROTH.—wild onion, (3), moist places, (P).
278. **Yucca angustifolia**, PURSH.—bear grass, soap weed, Spanish bayonet, (3), dry places, (P).

JUNCACEÆ, RUSH FAMILY.

279. **Juncus effusus**, L.—common rush, (3), wet places, (P).
280. **Juncus tenuis**, WILLD.—slender rush, (3), wet places, (P).

COMMELYNACEÆ, SPIDER-WORT FAMILY.

281. **Tradescantia Virginica**, L.—spider wort, (3), waste placess, (P).

CYPERACEÆ, SEDGE FAMILY.

282. **Cyperus phymatodes**, MUHL.—sedge, galingale, (3), wet places,(P).
283. **Cyperus strigosus**, L.—bristly galengale, (2) grass land,(P).

GRAMINEÆ, GRASS FAMILY.

284. *Eleusine Indica*, GÆRT.—crab grass, yard grass, dog's tail, wire grass, (2), neglected ground, (A).
285. *Eragrostis pœoides* var. *megastachya*, GRAY.—stinking grass, (2), neglected ground, (A).
286. *Bromus secalinus*, L.—chess, cheat, (1), grain fields, (A).
287. **Agropyrum repens**, BEAUV.—couch, quick, quack grass, (1), neglected ground, (P).
288. **Hordeum jubatum**, L.—squirrel tail grass, (2), neglected ground, (B).
289. *Panicum glabrum*, GAUD.—smooth panic grass, (3), waste places, (A).
290. *Panicum sanguinale*, L.—crab or finger grass, (2), neglected ground, (A).
291. **Panicum capillare**, L.—old witch grass, (3), neglected ground,(A).
292. **Panicum dichotomum**, L.—panic grass, (3), neglected ground,(P).
293. *Panicum Crus-galli*, L.—barnyard grass, cock's foot, (3), waste places, (A).
294. *Setaria glauca* BEAUV.—pigeon grass, summer fox-tail, puss-grass, (1), neglected grounds, (A).
295. *Setaria viridis*, BEAUV.—green fox-tail, bottle grass, (1), neglected grounds, (A).
296. *Setaria verticillata*, BEAUV.—whorled fox-tail, (1), neglected ground, (A).
297. **Cenchrus tribuloides**, L. hedge-hog or bear grass, (1) neglected ground, (A).

The distribution of the two hundred and ninety-seven species as to the length of life is as follows : annuals 84, biennials 27, and perennials 186, or nearly as 3: 1: 7, respectively.

If arranged according to the somewhat arbitrary scale of worse, bad and indifferent weeds, the figures would be 51, 94 and 152. The fifty-one worst weeds are distributed as follows as to their term of life: annuals 28, biennials 6, and perennials

17. This shows that more than half of the most troublesome plant pests are annuals. The second class of weeds includes those which interfere less with tillage and crop-growing, and are arranged as follows: annuals 34, biennials 12, and perennials 48. The tables are turned here and the perennials outnumber the other two classes.

The third group of weeds, which contains a trifle more than half of all enumerated, has 22 annuals, 9 biennials and 121 perennials.

The following table may be arranged for the more effective presentation of the subject:

	Annuals.	Biennials.	Perennials.	Total.
Worst weeds,	28	6	17	51
Bad weeds,	34	12	48	94
Indifferent weeds,	22	9	121	152
Total,	84	27	186	297

It will be seen that in passing from the worst weeds through the middle class to those which are termed indifferent, the percentage of perennials increase rapidly.

The eighty-seven foreign species may be tabulated as follows:

	Worst.	Bad.	Indifferent.	Total.
Annuals,	18	19	7	44
Biennials,	3	6	3	12
Perennials,	7	12	12	31
Totals,	28	37	22	87

The following is a condensed form for the two hundred and ten native species.

	Worst.	Bad.	Indifferent.	Total
Annuals,	10	16	14	40
Biennials,	3	6	6	15
Perennials,	10	35	110	155
Total,	23	57	130	210

At the first sight it is observed that more than half of the foreign weeds are annuals and that most of these are in the worst groups. More than half the indifferent foreign weeds are perennials. The native annuals are quite evenly distributed among three groups, while but few of the worst sort are perennial when compared with the thirty-five bad and the one hundred and ten kinds which are of the indifferent sort. As before stated, this last group includes many of the course plants of the prairie and the

unbroken areas along streams and other pasture land. Figures, however, do not show everything. A single species, for example, may make more trouble on the farm than several others in the same class, but the above table could not show this. The ten native annuals of the worst groups far excel in work of destruction, the ten perennials of the same class. Note the array of pests the first vile set includes:—daisy fleabane, great rag-weed, Roman rag-weed, cockle-bur or clot bur, beggar's ticks or bur-marigold sometimes called tick-seeds and pitchforks, horse nettle, beaked horse nettle, prostrate amaranth or pig-weed, knot-grass and the detestable bur-grass. Against these, the native perennials make a feeble array, among the worst of the ten being the quack-grass and the bull or pasture thistle.

This paper is only offered as a preliminary to the more thorough study of the subject, and remedies for the evil are intentionally left in the back ground. They will depend upon the circumstances which surround each case. Only a general prescription is offered. All annuals need to have perfect seed for the continuation of the species. To keep all such from "going to seed" is certainly a most effective remedy for the weed sick land The biennials are only few in kinds and they at most live only two years. Keep these from seeding by hoeing or mowing or some similar process. With the perennials the plan should be differeut. These pests take a firm hold upon the soil and need to be uprooted and burned or otherwise destroyed. They are frequently very tenacious of life but if kept from maturing seed and storing up nourishment for future growth they in time will be overcome. The leaves are the factories for food evaporation, and if these are removed the stoutest weed will ultimately die.

The best time to kill a weed of any class or nationality is while it is young. A mustard seed may lie dormant deep in the soil for many years, but when the plow has brought it near the surface, the sun and rain having quickened its life there only remains two courses to pursue either to live and grow, or die from lack of favoring conditions. Early culture is therefore the easiest, quickest, and most profitable method of weed killing. When this is pursued the soil at the same time receives the treatment most advantageous to the crop there growing and those that are to follow.

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Wild flax, 42.
Wild mint, 195.
Wild onion, 277.
Wild rose, 66.
Willow herb, 76–77.
Wind-flower, Pennsylvania, 1.
White lettuce, 165.
Wormwood, 144.
Yard grass, 284.
Yarrow, 141.
Yellow daisy, 125
Yellow false indigo, 63.
Yellow hop clover, 55
Yellow mustard, 17.
Yellow sweet clover, 56.
Yellow wood sorrel, 47.

STAMINAL OIL GLANDS OF CUCURBS.

Attention is here called to certain glandular structures which are found upon the stamens of cucurbstaceous plants. In plate 2, figure *a*, is shown a small portion of a transverse section through the coherent column of anthers of the early Jenny Lind muskmelon. The glandular bodies in question are flask-shaped and packed closely together in the spaces between the anthers; the anthers in this case have opened and discharged all their pollen. One of these bodies is shown alone at *b* and magnified two hundred times. It consists of a large cell terminating in a neck which is capped by a small extinguisher-shaped cell. This cap easily separates from the other part of the structure and at that instant there is a discharge of a large quantity of yellowish oily substance, induced

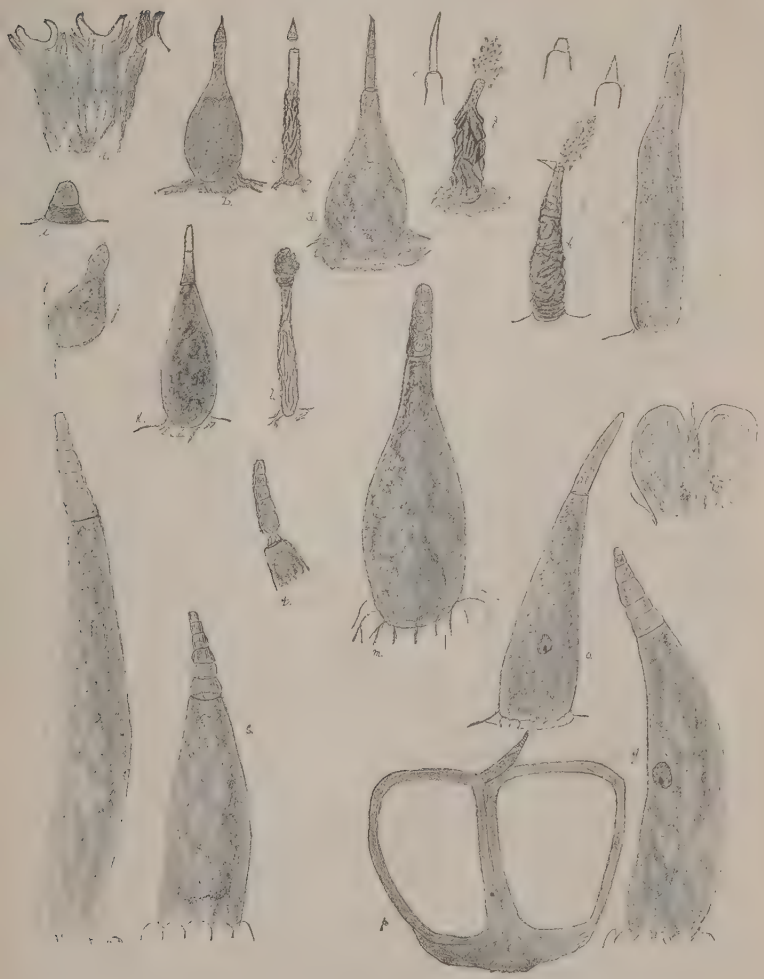

PLATE II.—Oil Glands on Anthers of Cucurbitaceous Plants.

by a rapid shrinking or collapsing of the body of the flask. At *c* is shown one of these outgrowths from which the cap has fallen and the walls have folded inward until it is of nearly uniform width throughout.

At *d* is shown a similar structure found among the anthers

of watermelons. All of the various sorts of flask-shaped bodies in the plate are drawn to the same scale. It is therefore seen that those of the muskmelon are much smaller than, as well of a quite different shape from, those of the watermelon. The latter is much more prolonged at the top, into an almost whip-like body. This extremity may consist of two cells as in *d* or of only one, shown at *e*. The place where the flask joins the hair-like termination is marked by a greater diameter and thicker wall of the neck. The appearance of a discharging gland is shown at *f*. The contents are more watery than in the muskmelon, and in an unbroken flask they include evident vacuoles of considerable size.

The next species shown is the wild cucumber (Echinocystis lobata, T. & G.) the antherial gland of which is of the shape and comparative size shown at *g*. It lacks the graceful shape of the previous two, being almost cylindrical in the body and has a neck and cap somewhat like those of the musk melon. When the structure collapses it draws down greatly, as shown at *h*, with the cap still hanging to one side. The range in the variation of the cap is indicated by the two outlines above *h*.

At *i* and *j* are shown the early stages in the development of these glands. At first there is a slight enlargement upon the surface; this shortly divides into two parts, as show at *i*, the upper becoming the cap while the lower grows into the large body of the gland. At *j* the process of development is seen more advanced.

The glands of another variety of watermelon is shown at *k* and *l*; these are essentially the same as *d*–*f*, but vary in the shape of the flask. The two cells of the cap were not constant but it may be possible that only one cell can be seen in the partly developed glands, the division wall appearing as maturity is approached.

At *m* is shown the form of the gland obtained from the stamens of the crook-neck squash. The whole structure has the form of an Indian club, the lower portion has orange-yellow granular contents which are arranged among numerous large valeuoles indicated in the engraving. The upper portion consists of four nearly equal-sized cells which contain much granu-

lar substance and a central vacuole. Four appears to be the constant number in this variety of plant. Figure *n* illustrates a transverse section of a small portion of the staminal column of the Hercules club gourd. The anthers are not open and the large gland is seen with its base on the line between the anther lobes. Its comparative size is seen at *o* and the curve commonly met with is also indicated. It is broadest near the base and gradually tapers to the end of the cap-cell which is long and not divided by any partitions. A prominent nucleus may be found near the middle of the basal cell. The dipper gourd has glands of this same type but the terminal cell is longer, more bent, and there is frequently a small cell between the basal and terminal one.

The nest-egg gourd glands are shown in *p* and *q*; their position is indicated in the first, and the shape and comparative size in the latter. It will be seen that the position on the anther is different from any other before mentioned. The pollen sacs are here quite large, represented by the two vacant places, and their walls lie close to each other. In short there is no place for these glands except at the outside corner of the anther. The gland is somewhat scythed-shaped, as indicated, and has six cells to that portion which corresponds to the cap in the other glands of the melons. The lower portion of the structure does not differ in contents or otherwise materially from *m* or *o*; a nucleus is manifest, and clear spherical spaces are interspersed with the granular orange substance.

Glands of great length were found on the stamens of the yellow bush scallop squash, one of which is shown at *r*; they have a comparatively narrow base and long scythe-shaped contour. The prevailing number of terminal cells was nine although it varied from eight to ten. As to contents of the great basal cell, nothing more need be said, as they are similar to those of *m* and *q*. Another variety of nest-egg gourd quite different in fruit from the first had glands as shown at *s*. It is somewhat smaller than *q*, but the position on the anther was the same. In this the lobes were separated by considerable spaces, but the glands stand out upon the corners as in *p*. The

number of terminal cells remains constantly six. At *t* is shown the manner in which the upper portion separates from the large flask-cell; the lower cell breaks away and soon the gland becomes emptied of its oily contents.

The purpose of these structures is not far to seek; they arise in connection with the production of pollen and pour out their contents upon the grains to make them adhesive and sweet. This not only attracts the bees but renders the large grains easily transported by the visiting insects. When mature the cap is easily removed, the difficulty being to get a ripe gland in the field of the microscope unbroken. Frequently while looking or making a drawing the object will collapse and suddenly discharge its contents upon the slide. The position of these glands upon the stamen is such that as the anthers are ruptured these glands are disturbed, often being hit on the prolonged tips by the reflexed turning of the anther walls. Insects also as they move about on the crown of the anthers will doubtless cause the discharge of the contents and at a time when it would seem to be of the greatest service.

After a thorough canvassing of the cucurbitaceous flowers it might be possible to arrange a key by which all species, and possible all marked varieties, might be distinguished by these anther glands. It is true that of the species studied there is a wide diversity and at the same time the glands of any given species are comparatively uniform. A single glance at the plate, which shows these structures, drawn to a scale of two hundred diameters, is enough to show that the differences are marked.

THE TWISTING OF PORCUPINE GRASS AWNS.

One of our most common prairie plants is the Porcupine Grass (Stipa sparta, Trin.). It sends up its showy panicles in May, each of which bears a large number of long-awned flowers. The awns as they droop, like tassels upon the slender culms, make the grass both conspicuous and attractive. As the weeks pass

the awns change from a soft texture to almost the hardness of bone. Below the ovary the pedicel shapes itself into a keen point and separates readily the remaining portion of the axis. The seed within the ovary, armed at one end with the short barbed stalk and at the other with the awn, six or more inches in length, is now ready to leave the place in the inflorescence and find another for germination. Before this end is reached the awns may often be seen twisted among each other in such a manner as to throw the lower, seed-bearing end out of the surrounding glumes and cause the sharp, basal barbed ends to be extended laterally. In this position they are ready to penetrate the wool or hair of passing animals and be carried away. After thus finding lodgement in the exterior covering they may penetrate the skin and become buried in the flesh of the unfortunate victim. Dogs often exhibit the keenest dread of these awns when sent into fields abounding with porcupine grass. Cases are on record of sheep being killed by the barbs reaching vital parts. It is evident that the barbs provide a means for the dispersion of the seed by fastening to the exterior of animals.

The peculiar structure above indicated also aids in the burial of the seed in the earth. As it falls to the ground the seed naturally strikes with the heavy seed-end downward and the long awn pointing upward. The natural condition is where the grass grows is a loose turf and with this the stiff hairs of the barb will hold the seed in whatever position gained. Any motion of the awn by wind or otherwise only tends to advance the seed toward the soil and even bury it in the turf.

Such generally understood facts as the above have led to a more thorough inspection of the awns, and the results in part are here given.

Gross Anatomy: The awns when they appear from the leaf-sheaf are green and straight, without any signs of tortion. It is not long, however, before there is a difference in the size, color and the appearance of the awn about midway from the free tip to the seed. There is an evident flattening in this portion and the color is of a yellowish cast. A little farther on in the his-

tory of the awn it is found to bend sharply at two points about an inch apart, within the flattened central portion above pointed out. Many of the awns, when this bending has proceeded for only a short distance, resemble an army rifle barrel with its bayonet set. Although the proportional distance to which the upper half of the awn stands to one side is much the longer than with the gun barrel and its bayonet. The peculiar bending might be spoken of as a double knee.

In order to better understand the curving, straight awns were carefully removed from the inflorescences and laid upon white paper, their position being recorded by pencil marks. It was found that bending began at once and within fifteen minutes the tips of some of the awns were rubbing against neighboring awns which at the beginning were two inches away. Some of the awns were much more active than others, and it was observed that when two crossed each other and rubbed their respective surfaces the curving was much accelerated.

Tests for the sensitiveness of the awns were next applied and with somewhat surprising results. The long, straight, freshly gathered awns were laid as before upon white paper and their positions marked by the pencil. In this series each alternate awn was first drawn twice, from base to tip, through the clasping finger and thumb. The other awns were removed from their attachments in the panicle with the least possible irritation. Within one minute an evident change had taken place in the rubbed awns, and at the end of fifteen minutes some of the tips had described an arc of ninety degrees and all of them averaged forty-five degrees. The unrubbed awns remained in the meantime in nearly their original positions and as straight as carriage whips hung by their tips.

The movement was of a double nature; at first there was the forming of the first bend or "elbow" by the lateral bending out of the upper half of the arm. About an inch above this was the seat of another sharp curvature, thus producing the bayonet shape before described. This double bending at the middle of the awn was followed by a twisting of the lower half of

the awn upon its own central axis. The twisting continued until the awn became as rigid as a small sized steel knitting needle. The number of twists can be easily counted, and they averaged from six to ten.

Experiments upon the sensitiveness were varied, for example, by filling a bread dish with sand and inserting the base of the seed (fruit) in this. Those in one half of the dish were stuck in with the least possible irritation, while the others were first subject to a rubbing as before mentioned. The awns which were not rubbed remained upright and with only slight movements for a long time, while those having been irritated, began at once to bend in a manner before described. A dish with

Fig. 1. Dish Containing Earth and Porcupine Grass Awns.

awns is shown in figure 1. There were additional advantages offered in this method for the study of the movements, because the whole of the awn was free to move. The first revolution, in several instances, was made in eight minutes, and the tips described a circle with a radius of fully three inches. A second revolution was sometimes completed in six minutes, and with the upper half of the awn in a nearly horizontal position at the close of the circuit. At this time the tip of one of the awns touched the side of a straight unrubbed neighbor and caused it to begin a similar movement but with less rapidity. At the end of half an hour the irritated awns had become much contorted; the tops were bent downward and the lower half of each had from six to seven twists. At the end of twenty-four hours the awns were twisted to their full capacity, but there was no manifest advance made by the seed into the sand. This was

doubtless due to the fact that the conditions were unusually unfavorable for that end. Each awn was by itself and the revolving upper portion could not obtain any foothold by means of which a downward motion could be effected. Had there been grass or stubble scattered amongst the awns the results would have been different. In figure 1 is shown a dish of sand the right end of which contains awns which had been rubbed before being set by their bases in the sand. On the left are awns which were not irritated. The contrast showing the awns after a half hour is very striking, and this method makes a good class-room illustration of sensitiveness in plants. The pan may be quickly set with the subjects before the class, and during the hour the remarkable movements of the rubbed awns may be noticed from time to time by the pupils and contrasted with the inactive ones which have been set with the least possible jarring and handling. The writer cannot recall any experiment that approaches this in neatness for the exhibition of irritability in plants to a large class.

After the awns had become completely twisted, water was added to the dry sand, none being placed directly upon the awns. In one minute the untwisting slowly commenced. The water from the sand gradually passed up the awn and undid the work of the previous day. As the sand and awns again dried out they slowly returned to the closely twisted condition and doubtless this process is often repeated in nature and thus the seed becomes buried in the soil.

When an inter-twisted mass of the awns is placed in a dish of water the motion is at first quite rapid. Each awn is untwisting and the upper end describes or tends to move in a circle. This lifts some of the other awns bodily into the air and these in turn getting a place of support push some others to one side. The equilibrium is not restored until each awn is straight and flexible. This will occur with recently twisted awns, in about a half hour, and when at rest the seed end will usually be at the edge of the dish, and, if the edge is slanting, some distance out of the water. It is evident that moisture has a strong tendency to scatter the seeds, or at least offers

them the conditions for scattering each other. These straight and lithe awns when again placed where they will dry out quickly, soon return to the twisted condition.

Experiments were made upon different portions of the awn as to their twisting properties. Five centemeter (c. m.) pieces of the base of several awns were separated when fully twisted, placed in water for twenty minutes; they elongated to five and a half centemeters (5½ c. m.) and the twists were nearly all out. The same lengths from the upper part of the awn, that is, above the double knee lengthened only one millemeter (1 m. m.) in the twenty minutes and elongated no more after fifteen hours. When 5 c. m. sections were taken from the awns so as to include the bends and placed in water as above described, the lower bend quickly disappeared and the upper one remained in for several hours.

Minute Anatomy:—Beginning at the base of the whole apparatus the seed is found to be awl-shaped in the ripe condition and made up of long fine cells packed closely together and inclosed in a hyaline horny sheath. This part is so dense that strong caustic potash will only slightly swell the tissue. A short distance above the smooth point, stiff hairs are found covering the whole surface and pointing upward. They are chestnut-colored when young and soft and silky, but later they become rigid and are straight, smooth and stand out like porcupine quills. When once the point has penetrated the clothing, wool or even flesh, it is held firmly in place by hundreds of these hair-barbs.

Just above the fruit there is a ring which marks the place where the awn separates from the part below. When viewed in their sections under the microscope it is found to consist of nearly spherical and very thick-walled cells packed closely together, while upon either side the cells, although of the same thickness, are several times as long as broad, and overlap each other like woody fibres.

The exterior surface of the awn below the first bend is coated with long hairs which are quite flexible. Between the two bends, which include an inch or more of the middle of the

awn, the outer edge is covered with teeth while the inner surface is smooth. From the second bend up to the free end, the awn is clothed with many sharp-pointed, stiff teeth, which extend upward. These teeth aid in holding the awn in place whenever it touches any object and thus tends to push the seed forward.

A transverse section of the awn near the seed shows that it consists of a small central vascular bundle surrounded by the very thick-walled cells before mentioned. The section is not circular but D-shaped. The awn can be divded into two similar halves in only one plane. In each such half is a belt of thin-walled, loose, chlorophyll-bearing cells easily distinguished from the thick bast-like cells which border this belt. A single layer of thick epidermal cells protects this delicate strand of cells. The two belts make up not more than one-twentieth of the whole section. The D-shape is more pronounced in a section made at the first bend. The bulk of the tissue is the same as lower down, but the thick-walled cells are larger and thicker, especially those which compose the two corners of the D. Two green belts are found and are situated near the angles of the awn. In short, the tissue here is all exceedingly firm and tough except the two belts of soft green cells which are just below the surface near the two corners of the awn. By this arrangement very strong and very weak cell tissues are brought close to each other in long belts and in a structure not equally balanced around a central axis.

A section near the tip of the awn shows a small central fibrous bundle surrounded equally on all sides by thick-walled cells. The green belts of parenchymatous tissue is not prsent. This part of the awn does not undergo tortion.

With this knowledge of the internal structure it becomes easy to locate the position of the two leading kinds of tissue by simply looking at the exterior of the lower portion of an awn without even a hand lens. Generally speaking there are four alternate belts of hard and soft tissue. In the untwisted awn these belts are all straight and in sight. As the tortion progresses the green, soft-celled and narrower belts become depressed or furrowed and finally are covered by the hard over-hanging

tough tissue. In the process of drying the thin-walled cells give up their moisture freely through the stomata, and as the cells collapse the D-shaped awn with the shrinking layers both upon one side can do nothing but twist and twist rapidly and closely. The return of moisture reverses the process and the collapsed cells swell, causing a straightening of the strands until they are again parallel and the arm is without tortion.

It is more difficult to explain the action of the rubbing. It seems to fall in with a long list of obscure cases of irritibility. From the very unstable structure of the awn it is evident that only a very little force is needed to throw the same out of the perpendicular. Whether the rubbing serves directly to contract the thin-walled cells or bring about this result by driving out some of the watery contents remains still unproved. There is a peculiar strand of minute cells which runs along one side and within the chloroplyll-bearing belt, touching the thick-walled cells upon one side. This may prove to be the avenue by which any impulse is transmitted. From this the influence may spread throughout all the surrounding tissue.

The present paper only serves to open up a wide field for further investigation, and it is hoped that many questions may be answered in the near future that are now left unstated. Teachers of botany and all others interested in the movements in plants have their attention particularly called to the excellent illustration for class use of the awns of this stipa.

ASPARAGUS STEMS HELIOTROPIC.

The common garden asparagus is heliotropic. This movement toward the sun was quite marked last spring as observed from time to time, while the tender shoots were growing, in a large bed belonging to the College. In early morning the shoots are nearly upright, but when the sun is two hours above the horizon the same stems lean unmistakably to the eastward. In looking toward the north over a large area of asparagus stems this heliotropic property is evident to any one whose attention has been called to it.

At noon the stems are leaning somewhat to the south and at evening they point westward. The curving is most prominent with average sized stems which have escaped the gardener's knife and are between one and two feet in height. After the stems get woody they are more ridged. In short, the curving is greatest when there is the least resistance. The asparagus stem when it is young, tender and growing rapidly might become a valuable subject for experiments upon the heliotropic property in plants.

In this connection it may be mentioned that the foliage of the common mallow of California (Malva borealis, Wall.) was observed last winter to be highly heliotropic. This weed springs up everywhere in neglected land and covered large areas near where the writer was quartered for the season. In the forenoon all leaves, which were not old and woody, turned their nearly circular blades to the sun. The upper surface was kept perpendicular to the solar rays until the sun was nearly setting. From this time, and through the night, the blades retraced their tracks, and when the next morning came they were ready to catch the nearly horizontal rays. Many observations were made upon the plants both during the day and night, and the results have already appeared in the *Botanical Gazette* under the title of "A Plant Heliostat," pages 82-83, 1887.

IRRITABILITY IN PURSLANE STAMENS.

However bad a weed the common Purslane (Portulaca oleracea L.) may be in the garden and neglected ground, it is a valuable plant to the student of vegetable anatomy and physiology. Its brittle, succulent stems furnish one of the best subjects upon which the beginner can practice with razor or scalpel. They also illustrate the exogenous bundles in all their stages of development, and in crystals, chlorophyll grains, and other forms of cell-contents the leaves furnish abundant subjects for study. For general purposes the purslane is one of the best laboratory plants we have.

But perhaps the greatest interest has centered in the flower. The little yellow blossoms are as shy as they are beautiful. They are open when all conditions are most favorable for fertilization through the visitation of insects. The day must be warm and sunny, and then the bright eyes will peep out from among a wealth of succulent stems and leaves. By midday they are usually forever closed, unless perchance a shower has come in the forenoon, when the lemon-yellow petals quickly fold inward and the two green sepals rise and cover all parts, and the flower awaits the drying influence of the hot summer air. When the flower has passed blooming the young pistil, by reason of its green color and adherent calyx, bears a close resemblance to an unopened bud, and almost before a sharp observer is aware the plant will be loaded with a vast crop of ripening seeds. The time required for the maturing has been determined by a student this year and is stated elsewhere as averaging ten days. The prolificacy of a good-sized plant well situated was carefully estimated to be not less than a million fold, and a single neglected plant will therefore stock a large area with seeds.

The point which has attracted the most attention for the past two years has been the sensitiveness of the stamens. These organs are ten in number, with very slender almost hair-like filaments terminated in comparatively large anthers with the two lobes widely separated by a broad connective. When the flower is open in the bright sunshine the stamens are disposed regularly in a whorl and the style and its fine slender spreading stigmas are prominently in the center. If one of these stamens is touched by a pen or pencil point it instantly begins to move and the direction is toward the side which came in contact with the irritant. Thus if the pencil is brought against the corolla the stamen moves outward and away from the pistil. When the touch is upon the inside the anther is brought upward and close to the middle of the flower over the pistil. In the same manner the movements may be lateral, that is, at right angles to the directions above stated. A stamen can be made to move in all these directions consecutively. For ex-

ample, it may bow outward then inward and next to the right side and afterward to the left. Or, by extreme delicacy of manipulation (for the flowers are small and the stamens inserted near each other) a filament may be caused to bend in several directions in such a manner that the anther will describe a circle. The movements of a fresh stamen are at first rapid, and it is difficult to adjust a hand lens before the bending is finished, but if the same stamen is irritated a number of times the movements become less prompt and through shorter distances; it finally becomes insensible to the touch and only recovers irritability after a few minutes of repose.

A microscopic examination of the base of the stamen shows that a tuft of short, somewhat curved and broad, blunt hairs is situated at the point of union of the filaments with the petals, upon the side opposite the pistils, while toward the style and a short distance above the first mentioned hairs there is another similar set. These outgrowths are much like the stigmatic surface of the pistil of many plants. No experiments have been attempted to establish the relation, if any, which these hairs bear to the movements in question.

Many small insects visit the purslane flowers and crawl among the slender filaments on their way to the sweets below. If a fly creeps close between the corolla and stamens it causes the latter to move outward and this assists in getting the pollen upon the body of the insect. Should it make its way between the stamens and pistil a corresponding movement accomplishes the same result.

The cultivated purslane or "moss rose" (Portulaca grandiflora, L.) has a much larger flower and is a better subject for class illustration of sensative stamens, but less valuable for a patient investigation. In this the stamens are numerous and with their large anthers fill the space within the petals so completely that it is not easy to study the movements of any particular stamen. By rubbing a pin over a dozen or more anthers at a time, they will all move in concert in the opposite direction from that of the pin. An insect entering the flower upon one side will irritate the stamens and bring them over its body,

and in extricating itself will become covered with pollen from the ripe anthers. Since the above observations, the article by Dr. Bessey* has been read with much interest. Many of the facts concerning the native purslane are not therefore offered as new. The plant, however, is so available and illustrates irritability so admirably that it should not be lost from sight by any teacher.

Both species of portulaca are also excellent for the study of pollen-tubes and their entrance into the stigma. Those of P. grandiflora are much larger and therefore better for the use of students. Take it all in all the structural botanist should regret, upon a strictly professional basis, to part with the purslanes.

OBSERVATIONS UPON LYTHRUM FLOWERS.

One of the best illustrations of dimorphism among our wild plants is seen in the flowers of our leading representation of the Loosestrife family, namely the Lythrum elatum, Pursh. The blossoms of this species have been examined in great numbers during the past two years and students have become much interested in the heterogenous dimorphism presented by it. The differences of floral structure are confined to the essential organs—those immediately active in the production of seed. In the long-styled flower the six stamens have their anthers on a level with the upper edge of the corolla tube, while the style projects a short distance above them. The positions are exactly reversed in the short-styled form. The stamens are not, however, all of exactly the same length in either case. These differences are most noticeable in the form having the filaments protruding beyond the tube of the corolla.

Coming closer to the subject, a study of pollen and stigmatic surfaces shows interesting microscopic differences which furnish the material for this paper. The pollen produced in the anthers of the long stamens is of a beautiful pale green, and in striking contrast with that of the short stamens. This marked difference is readily seen without the aid of even a hand

* American Naturalist, Vol. VII p. 464.

lens, either by looking at the ripe ruptured anthers or when the two sorts of pollen are held upon the hand, or better, in a porcelain dish.

The green pollen of the long stamens is very constant in its size, and being smooth and spherical when wet the measurments are easily determined to be from 36 to 39 μ with an average of 37 μ. Applying the same scale to the spherical colorless grains they were found to average only 27 μ, or a little more than two-thirds the diameter of the pollen of the long stamens. In actual contents the differences are as nine to four in favor of the long stamens.

The stigmatic surface is also found to differ in the two kinds of pistils. The styles of both sorts end in an enlarged tip, or is capitate, but in the long style this is hemispherical, and consists of long slender projecting cells which are of uniform width throughout. These outgrowths or papillæ are set close together upon the top of the style but being five or six times as long as broad they give a penicillate or brush-like appearance to the stigma as viewed under the microscope. The stigma of the short-style has a more flattened top, but with about the same breadth as half the stigma of a long style. The stigmatic surface, however, consists of short thick-set pear-shaped papillæ about half as long and twice as broad as the projections making up the exposed surface of the stigma of the long style.

Fig. 2. Pollen and Stigmatic Surfaces of Lythrum Elatum, Pursh.

Pollen of both kinds was sometimes found upon the same stigma, but the sort intended for any particular stigma was usually the most abundant and active. Experiments in germinating the pollen in sugar solution did not develop any marked differences and there is no apparent reason why there should be any.

In figure 2, *a* represents the pollen from the short stamens, *b* of the long stamens, *c* the stigmatic papillæ of the long-styled stigma and *d* of the short style. All parts are drawn to the same scale.

OBSERVATIONS ON THE OXALIS.

The little yellow wood-sorrel (Oxalis corniculata var stricta Sav.) is a variable plant in central Iowa and abounds everywhere, flowering from early spring until the growing season closes in October. In its dwarfed form it covers otherwise bare spots in meadows and pasture; with a long slender habit it flourishes under the cover of surrounding grass or shrubbery and attains its greatest size in both stem and flower when growing on the rich moist banks of streams. Along with a sister species (Oxalis violacea, L.) much less prone to stray from the specific type, it almost invariably appears in the spring collection of every botanical student. Common as it is, this sorrel has peculiarities which interest the lover of plants. In its varriations there are suggestions, which it is hoped some day may lead to the discovery of facts of wide application.

When the flower has gone there still remains much to please even the tyro in the study of plants. If a quantity of the oxalis be gathered in autumn and placed on a table there will soon be a surprising illustration of seed distribution. From plants, apparently already passed into that long sleep from which only the quickening impulses of a new spring can arouse, there will be heard all the noise of a miniature battery attempting to subdue a garrison by the unexpected and interrupted firing of shot and shell. The ripening pods have become mortar guns and each seed is a missile in this peculiar bombard-

ment. Students are sometimes puzzled in determining the method by which the seeds are so violently expelled. Sufficient time is not given after the capsule is touched for an inspection of the manner in which the forces act. Almost as quickly as the touch-me-not hurls its seeds the oxalis pods discharge their contents, sometimes throwing the seeds several feet away. Unlike the impatiens, however, the capsule is not destroyed but prepares for another shot, until all the seeds have been expelled. Even after the work is over the capsule retains its general shape and hangs as a flabby vessel to disappoint the one who touches its emptyness expecting to witness the sudden scattering of its contents.

The pod, shown at *a*, plate 3, is about an inch long, of the size of a goose quill and consists of five seed-vessels or carpillary leaves closely united along the central line and each with the upper end prolonged into a slender style. The seeds are borne in a row in each of the five cavities and are attached to the placentæ along the central column. As the capsule matures each of the carpels develops a slit along the dorsal suture marked *x* in the cross section of a capsule shown at *b*. The edges of the two valves fit together at this line like the two broad tips of a pair of forceps. A further growth of the capsule brings a ridged appearance which is due to a thickening of each valve at a point (y.) about midway between the suture, *x*, and the central column, *z*. As a result of this development there is a possible passage-way the whole length of the exposed middle of each cavity, but kept closed by the peculiar structure of the valves. The inner surface of the valve, that is the boundary of the seed cavity, is covered with many stiff hairs with irregular protuberances upon the surface of the upper half. One of these spinose structures is shown at *c* while an enlarged view of half of a cavity—one valve, is shown at *d*.

The outer covering of the seed as it matures within the capsule is almost pearl-white and exceedingly tough and elastic. When the seed is ready to be discharged—it in the mean time having grown to fill the whole of a portion of the long slender cavity and its surface therefore brought against or close to the

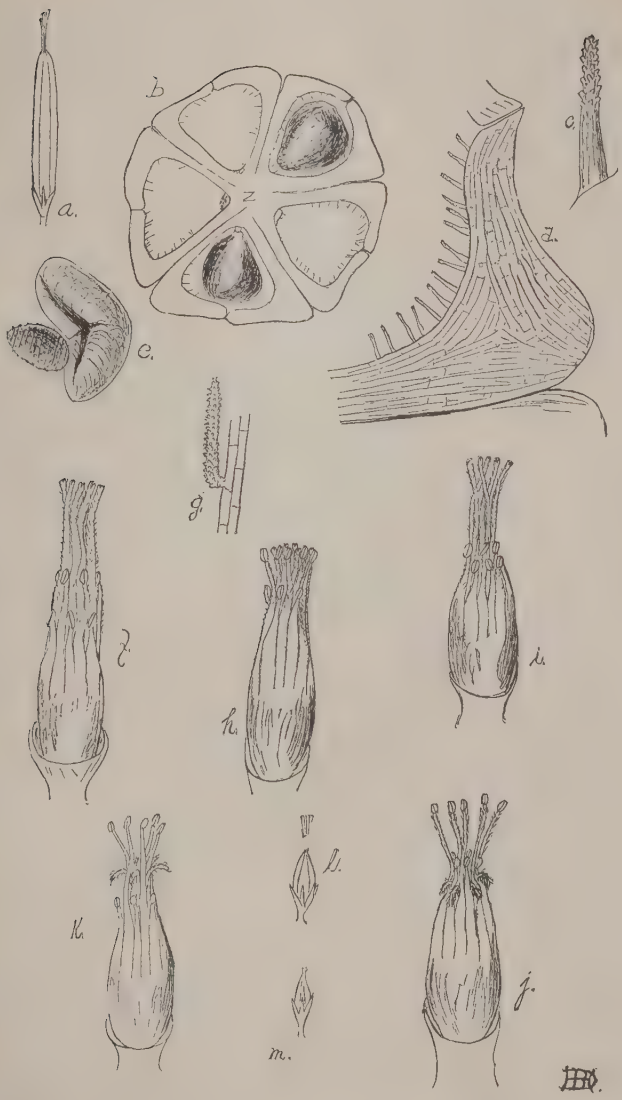

PLATE III.—Dimorphism in Oxalis Corniculata Var. Stricta, Sav.

ends of the inward projecting spines—only a touch is needed to cause the exterior layer to rupture in one or two directions and coil back upon itself as shown at *e*. If this opening is made along the outer side, and it usually is, because that portion is most exposed to exterior influences, the instant spreading apart of the halves of the elastic coat throws open the valves and the seed darts out of its coat and at the same instant is liberated from the capsule. The seed as thus set free is oval, somewhat flattish, chestnut color and beautifully ridged with alternate furrows and lines bearing multitudes of fine projections. This irregular surface doubtless serves to keep the outer layer in place until it becomes dry and exceedingly elastic. Very likely the valves of the capsule may aid in the expulsion of the seed in the same manner that moist apple seed may be propelled by pinching between the thumb and finger-tip; but that the primary force reside in the exterior coat is easy of demonstration. Seeds may be removed from the capsule before they are fully ripe, or ready for dispersion. Such when left for a time upon the table will be thrown for some feet when touched by a sharp point as that of a needle or pen. The white outer coat ruptures so quickly that it is impossible to watch the movements and an instant after the chestnut seed may be on one distant part of the table while the closely rolled and twisted pearly shell is perhaps lying in another direction from the point of departure. The quick action following the puncture of the pen point suggests that the sharp stiff hairs within the capsule or seed cavity may serve the same purpose when any pressure is brought upon the exterior of the pod. There is a very perfect adjustment between the size of the seed, elasticity of the outer coat and the structure and firmness of the valves which secures the discharge of each seed as it matures.

The point which has been of most interest in the study of this little species is the dichogamous tendencies in the flowers. As before stated there are five styles. The stamens are twice that number and arranged in two sets of five each. These stamens are all united by their filaments which form a ring around the base of the pistil. A flower with the calyx and

corolla removed is shown at *f*. The filament ring can be easily split upon one side and the andrœcium spread out flat upon a glass slide. Under the microscope as thus arranged there is a marked difference between the longer and shorter stamens even when the difference in length is but the breadth of the anthers. The shorter ones are smooth upon the surface while the longer set has many peculiar sharp-pointed hairs which are stiff, covered with blunt projections, and extend almost directly upward. One of these hairs is shown at *g*. In passing it may be said that the same structures were found similarly disposed on the stamens of Oxalis violacea, L. The same sort of outgrowth abundant upon the styles, being larger and more numerous than upon the long filaments.

The dwarfed variety of our subject, on poor, dry-ground, exhibits a considerable variation in the stamens, but they all belong to one type, namely: two lengths, the anthers of the long stamens being about equidistant from the other anthers and the stigmas, as shown in *f*. The variations are always in the relative lengths of the three sets of organs and never in an interchange of their positions. Among hundreds if not thousands of flowers examined no instance was found where the stigmas were between the two circles of anthers or below them both. It was, however, not uncommon to find the long stamens and the styles of the same length as shown at *h*. With such small flowers it is only a matter of a tenth of an inch to bring about the change of place anxiously looked for and expected. Another variation was where the stamens were nearly of the same length and the styles were very long. This form is indicated at *i*. If the last two forms are considered by themselves without noting intermediate stages it would not be difficult to make out a long and a short-styled form, but at the same time the stamens do not match these lengths as in case of well established dimorphic flowers.

An inspection of the larger flowers of the coarse, long-stemmed and spreading form common along the banks of streams yields somewhat different results. The leading form of flower has large slender styles far exceeding the two sets of

stamens which were with anthers quite close together, as in *i*. A less frequent form has the styles short and thickish and turned out laterally between the filaments of the stamens as shown at *j*. The upper set of anthers is upon long slender filaments and the other considerably below midway between the long-stamen anthers and the style-tips. On October 25th this river-bank oxalis was used in class and the flowers carefully studied. Each student had a whole plant with several flowers. Of the fifty-eight examined, forty-nine were long-styled and nine short-styled. These figures of five to one may be taken as the average ratio of these two forms. The trained eye quickly learns to recognize the difference and may readily distinguish the form from the styles remaining upon mature pods. This is mentioned to impress the fact that the two forms are very distinct.

Perhaps the most interesting fact was the failure to find any mid-styled form. There are three possible combinations of the three lengths of organs and it is natural to expect them all when two are present in the species. For example the plan when complete should give a form with styles to match the lower stamens in *j* and the upper ones in *i*, the others being provided for. It may be that further search may reveal this missing link, but whether it be found the interesting intermediate conditions remain to indicate that the the oxalis has not reached that stable condition when its floral forms are constant as is seen in such plants as primulas, lythrums and similar typical dimorphic and trimorphic species.

The upland or dwarf form suggests the primary condition of the floral organs, where the styles are longer than both sets of stamens or at the best equal to the longer set. This may be taken as a variation from a primitive type when the styles were long and the stamens shorter and all of one set.

In midsummer plants struggling to make a feeble growth under unfavorable conditions the stamens were frequently with filaments of almost the same length. The more vigorous plants exhibited the greater separation of the circles of anthers and also greater variation in style-lengths. When we come to the

stoutest of all plants of the species the separation is into two distinct lengths of styles and stamens.

The evidence is not sufficient to decide whether the species is striving after trimorphism or being once trimorphic is drifting into monomorphism. The indications are that the former view is correct. This is in accordance with the prevailing tendancy of evolutionary laws —the passing from the simple to the more complex. Heterostyled dimorphic plants have many advantages for a wide fertilization not secured in the monomorphic species, and it is reasonable to believe that the former have developed from the latter, through long periods of time and under the stimulus of insect visitors working in connection with the underlying principle of the survival of the most improved forms.

An examination of the pollen reveals the fact that in the dwarfed form there is no decided difference in size between the two lengths of stamens. The average was 40 *u*, and with only little variation. With the strictly dimorphic plants the following figures were obtained:

LONG-STYLED FLOWERS:

Long stamens.....43-45 *u*; average.....44.25 *u*.
Short stamens.....36-45 *u*; average.....40.00 *u*.

SHORT-STYLED FLOWERS.

Long stamens.....40-45 *u*; average.....42.5 *u*.
Short stamens.....48-40 *u*; average.....41.0 *u*.

The figures indicate a lack of fixity of type, which suggests that the species is unsettled in its forms of the essential floral organs.

NOTES UPON POLLEN.

The pollen of a large number of plants has been examined during the past year. In many instances the pollen of closely related species were measured and their forms studied with a view to obtaining, if possible, a quick method of determining the species when other characteristics were obscure or the parts entirely wanting in the specimen. Thus the pollen of Lobelia syphilitica L. were found to resemble that of Lobelia cardinalis L. in every particular. The former are a little larger, being 30

to 31 μ in diameter while those of the latter are 28–30 μ. These differences are so minute that practically the pollen of these closely related species are the same. Some plants of the L. syphilitica, L were found with a dicided tinge of the cardinal flowers (L. cardinalis L.) and it may be that the variation is due to cross-pollinization and fertilization. These two plants may offer fine subjects for testing hybridization and the influence of the parents because the flower of one species is a deep blue while of the other it is a bright cardinal.

Datura Stramonium L. and Datura Tatula L. have pollen that are not distinguishable. The grains are large, spherical and vary in diameter from 65 to 72 μ.

Ambrosia artemæsiafolia, L. and Ambrosia trifida, L., have the same character of pollen, echinulate and spherical, 24 26 μ. The grains are not more than one-third the diameter of those of the daturas. If we were to generalize from the results already given it would be that closely related species have like pollen, while widely separated plants possess very different pollen.

By taking plants in the same natural order but in different genera as the Virginia creeper, (Ampelopsis quiquefolia, Michx.) and the wild vine (Vitis riparia, Michx.) it is found that the pollen has the same appearance and measurements, namely : 27–30 μ. In a separate article the pollen of the grape is considered at length.

Red clover (Trifolium pratense, L.) has a nearly spherical pollen of a cinnamon brown color and containing many vacuoles or watery places—45–54 μ. The pollen of white clover (Trifolium repens, L.) is very different; it is irregular, shaped somewhat like a clover seed, has no vacuoles, is colorless and only 30 36 μ. We thus see that by a study of a larger number of cases the conclusion cannot be that species of the same genus always have pollen of the same general type. Alsike clover has pollen which agrees very closely with that of the white clover. The albino red clover—a quite common sort in this vicinity, has as was expected, the same quality of pollen as the normal or red sort.

Yellow melilot (Melilotus officinalis, Willd.) has an irregular somewhat elliptical pollen, 30 by 38 μ and medick, lucerne

or alfalfa (Medicago sativa, L.), very closely related, has a beautiful clear spherical pollen averaging 45 μ in diameter.

A common smartweed (Polygonum Pennsylvanicum, L.) has a large pollen 60–65 μ and marked as if enclosed in a lace network. The black bindweed (Polygonum Convolvulus, L.) of the same genus produces a widely different pollen only 20 μ in diameter and without any of the markings seen in the smartweed. In this case the genus is a large one and is readily separated into subgenera upon the floral parts and other characteristics. The two species here given belong to strikingly different groups under the large genus. It may be true that the size and markings of the pollen would furnish a quick means for the identification of the divisions of this troublesome assemblage of plants.

The largest pollen examined was that of the nest-egg gourd (Cucurbita ovifera, L.) It is spherical, very spinose and from 170 to 180 μ in diameter. All the pollen of the members of the gourd family (cucurbitaceæ) is large. The garden iris has a large and beautiful pollen 110–120 μ. When placed in water the thick reticulated outer coat slips off and leaves the granular contents with two distinct hyaline walls which swell greatly when free from the rough outer layer.

In striking contrast with these large sorts of pollen is that of a cultivated variety of Philadelphus varying from 15 to 20 μ. The flowers of this plant were undergoing the process of "doubling" and tests were made for the germination power of the pollen borne by stamens which were nearly transformed into fully developed petals. It was found the pollen from anthers which were mere specks upon the tips of the inner petals grew quickly in sugar solution and manifested as much vitality as that tested from perfect stamens.

The pollen of several species of grass was examined and in many of these the circulation of protoplasm was observed. Blue grass pollen is very plump and when in water, spherical; the coat is thin hyaline and the contents granular; size 40 μ. Looked at when dry this pollen exhibits the streaming of the granular contents. A one-eighth Tolles objective shows that the protoplasm is in threads which ramify among the vacuoles.

and along these threads the granules move. Similar movements are seen in the pollen of the orchard grass (Dactylis glomerata, L.) but the grains as a whole are quite variable in size—38–45 μ. This fact of the uniformity in size of the pollen of one species while in another there is a wide variation may have its bearing upon the stability or otherwise of a species. Uniformity in pollen may be a measure of the acquired characteristics of a species. It has been a fact of observation during the past year that varieties and hybrids usually exhibit a wider range of size than wild species of the same genus.

The pollen of the oat grass (Arrhenatherum avenaceum, Beauv.) is oval 30 by 48 μ and with the nucleus evident. That in the staminate and perfect flowers is practically the same. In one instance the feathery stigmas of a young unopened flower was found bearing hundreds of pollen grains with their tubes extending far into the styles. The pollen had been discharged from the anthers before the blossom opened and this may be taken as a case of close pollinization.

In the pollen of field rye the two nuclei are easily seen without the use of any coloring agent. These nuclei are about equal in size and surrounded by the protoplasmic mass which is irregularly disposed within the hyaline coat inclosing large vacuoles. The grains are ovate and average 36 by 54 μ.

Wild barley (Hordeum jubatum, L.) has nearly spherical pollen which is quite uniform in size 34–36 μ. The denser contents form a crescent in optical transverse section, the greater part of the interior of the thin coat being occupied by a watery substance. Two nuclei may be easily seen in the crescent of protoplasm.

Pollen of several flowers with more than one length of stamen was examined. The Kentucky coffee tree (Gymnocladus Canadensis, Lam.) is nearly a dioecious species although some of the pistillate flowers may have abortive stamens. In the male or sterile flowers the stamens are arranged in two distinct whorls, the members of which alternate with each other and differ but a little in length. The averages for a long series of experiments gives for the pollen for the short stamens 39–43.5 μ and for the long 39.3–44.6 μ. There is practi-

cally no difference. However the short stamen pollen germinated much more quickly in the sugar solution than did that from the long stamens.

In black mustard (Brassica nigra, L.) the long and short stamens bear pollen of the same size 30 by 45 μ. The same is true of the garden radish which has much smaller grains. Several other cruciferous species with their four long and two short (tetradynamous) stamens were examined but with the same results.

The pollen of several plants in other orders having two length of stamens, as the mints and figworts, were inspected, but it was found to be of only one size, which however was quite variable. Toad flax (Linaria vulgaris, Mill.) for example has pollen 27–28 μ. for both its long and short stamens. The two most exceptional cases found during the year, namely oxalis and lythrum, are separately treated elsewhere.

Among the most interesting pollen studies was that of the common mandrake (Podophyllum peltetum, L.) As the grains become scattered through a drop of water upon a glass slide it is quickly seen that they adhere in clusters of four, and might be illustrated by fastening four spherical lead bullets in a group by cutting four smooth places upon each for attachment. Usually one grain is smaller than the others, and rarely two are smaller. The average size of the smaller is 34–36 μ and of the larger 40–45 μ. The larger grains are clear, having the con-

FIG. 3. POLLEN OF MANDRAKE.

tents homogeneous, while the smaller ones are opaque and exhibit many granules, besides the two nuclei. Upon subjecting

these compound masses to the action of the culture liquid the smaller grains soon produced tubes of a very contorted nature while the other grains failed to show any signs of germination. In only one case were tubes found growing from two grains in the same cluster. In figure 3, *a* shows one of the pollen masses with a single grain nucleated. At *b* two are seen with nuclei. At *c* and *d* are instances of the germination of the smaller grain in each group of four. The history of the development of these united grains has not been worked out at this laboratory and it is hoped that more light may be thrown upon the subject the coming spring.

EXPERIMENTS WITH GRAPE POLLEN.

The common wild grape, (Vitis riparia, Michx.) has two kinds of plants, namely: those which are fruit bearing, and the sterile vines. In the former the flowers have both stamens and pistils, while the latter has blossoms with stamens only or at least the pistils are abortive. The perfect flowers have small stamens which, as soon as the cap is removed, curve outward and downward; in other words the stamens are reflexed. In the truly staminate flowers the filaments are much larger than in the perfect blossoms and remain upright; the stamens are not reflexed. The anthers of both sorts of stamens produce pollen and of the same size, namely, 27–30 *u*.

The pollen experimented with was taken from anthers of the two sorts of stamens freshly opened. At 9:40 A. M. of May 22d, two slides were prepared with 35 per cent. solution of sugar and pollen from the reflexed stamens of a fruit bearing vine was placed in one, while the other slide of germination mixture received the pollen from the staminate plant. Twenty minutes after the pollen for staminate flowers had formed the characteristic bulb or swelling to one side, but none of the grains from the perfect flowers had manifestly changed. At this point two other slides were prepared with pure water and the two kinds of pollen added as before. After thirty minutes the pollen from staminate flowers had the bulbs fully developed and many grains were pushing out the tube from the bulb. In the fertile flower pollen no such growth was to be observed and the

grains were apparently the same as at the beginning of the experiment. A half hour later some of the grains from staminate plants had tubes 150 μ in length. Those in the sugar solution were somewhat slower than in the pure water and the bulbs were begining to develop the tubes. The pollen of the perfect flowers were still in the same inactive state as an hour before.

It only needs to be said that the tubes of the pollen of the staminate plant continued to grow from hour to hour until the long slender somewhat zigzag filaments formed an almost entangled mass. On the other hand the pollen of perfect flowers failed in any instance to develope a tube or a bulbous begining of one.

In the engraving figure 4 *a* shows the appearance of the dry pollen; *b* indicates the germinating grain, a clear spherical mass or bulb forming at one side. At *c* is shown a grain of the perfect flower pollen after many hours in sugar solution.

FIG. 4. POLLEN OF WILD GRAPE.

The other figures show grains at different stages in their growth. The one at *d* has the tubes extending from one side of the bulb, two hours after being placed in the liquid. At *e* is shown a grain one hour after its treatment begun. The ones at *f* and *g* are quite like a tobacco pipe; *h* indicates the wavy outline sometimes made by the tubes, in contrast with the direct course of *i*. At *j* is another of the sterile grains like *c*.

A second experiment was made with stigmas. These were gathered when receptive as indicated by the drops of glistening liquid upon them, and placed five in a set, upon glass slides in a moist chamber. One set was pollinized with staminate flower pollen and the other with grains from perfect blossoms. After two hours no signs of any tubes were observed on stigmas receiving pollen of perfect flowers, but in the other set many grains had germinated and their tubes were finding their way into the stigmatic surface. At the end of twenty hours no

staminate flower pollen was found germinated. As the stigmas are only receptive for a day or so this experiment was of course terminated.

A third trial was made with the two kinds of pollen by placing considerable quantities in two porcelain dishes containing 25 per cent. sugar solution. The pollen from staminate flowers in four hours produced tubes from five to ten times their diameter and in twenty hours this length was more than doubled. The dish containing the pistillate flower pollen at this time showed no germinated grains.

It will be seen that in all the tests, in water, sugar solution or upon stigmas there was but one uniform result. The pollen from the large upright stamens of the sterile flower of male plants grew in every instance, but that of the reflexed stamens of perfect flowers failed in all cases. More trials are, of course, necessary to warrant the assertion that the dwarfed recured stamens of the pistil bearing flowers never produce pollen with the power of fertilizing ovules. However the evidence points in that direction and Vitis riparia is practically a dicecious species in which the male plant bears vigorous, upright stamens surrounding an abortive pistil, while the female plant has flowers possessing well developed pistils and a circle of inferior stamens which became reflexed, and as far out of the way as possible when the blossom has lost its corolla-cap. These stamens have their filaments closely folded together in the bud and they doubtless are useful in removing the cap, and this may be sufficient reason for their retention in the blossoms which they do not otherwise serve. After this removal has been effected the filaments become reflexed and this throws the anthers out of the range of visiting insects and at the same time prevents close fertilization. The upright stamens of the male flowers are crumpled while inclosed by the cap, but upon its removal they straighten up and stand in the way of attendant bees. The pistil is not retained to aid in the removal of the corolla and is reduced to a flatish disc.

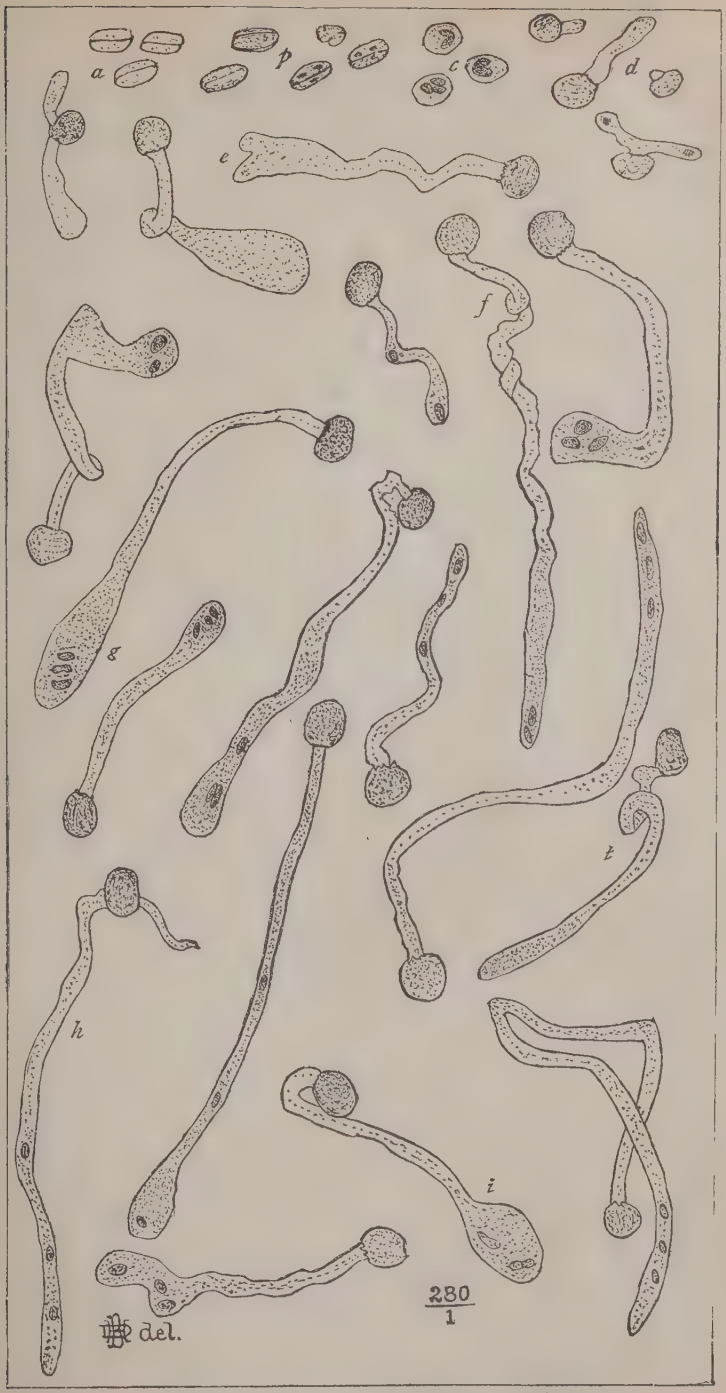

PLATE IV.—Pollen with Three Nuclei.

THREE NUCLEI IN POLLEN GRAINS.

The pollen under consideration was obtained by placing twigs of Sambucus racemosa in a tall bell jar of water on March 3d and keeping them in a warm sunny room. The experiment was begun primarily to illustrate to students the effect of coating the cut surface of the severed twig with asphalt or a similar substance impervious to water. There were four similar twigs each eighteen inches long, placed in the water. Two of them had their cut surfaces coated with varnish, while the remaining two were set in the liquid with the freshly cut ends fully exposed. The asphalt used was that employed for cementing cover glasses to the slides in making permanent microscopic preparations. The buds upon the stems having free cut surfaces quickly began to enlarge, while those of the twigs that had received the varnish did nothing more than slightly swell, and never produced any leaves. The unvarnished stems sent out their characteristic foliage, and at three of the nodes flower clusters of considerable size were developed. It was from these flowers that the pollen was obtained for the observations herein recorded.

The above facts are given because there may be a difference between the behavior of the pollen thus forced before its time and that which would have been produced normally upon the shrubs several weeks later in the season.

When viewed dry, the pollen is about twice as long as broad (20 μ by 40 μ), and exhibits three dark lines or sutures which run lengthwise of the grain. The appearance of the dry grains is shown at a in the plate. All the illustrations were were drawn with the camera to the same scale and are magnified two hundred and eighty times. To the left of p are two grains showing the surface of the dry grains. The extine is marked with faint irregular lines, resembling a network of minute cells. This slight obstruction to the view quickly disappears when water is added, and at the same time the grains become nearly spherical and lose all signs of the original tripartite nature. When treated with a mixture of half water and glycerine the nuclei are easily seen. On the right of p are three

grains; the upper one shows an end view with the three division lines of the grain. Below this are two grains in which the nuclei are evident. There seems to be a nucleus for each third of the grain. After pollen has been in pure glycerine for two days the grains become plump and the contents are nearly colorless, except the nuclei which are large and well defined. Three such grains are shown at *c*. In many instances the nuclei seemed united by their ends, while in others all three were evident.

For germination fresh pollen was placed in a ten per cent. solution of cane sugar in one of a nest of porcelain macerating dishes and after forty hours the tubes were of the length indicated in the plate. The earlier stages of germination are shown at *d*. Usually there was a single tube, but occasionally the tube branched as it issued from the grain. In some cases there were two points of departure, as shown near *a* and at *h*. The course of the tube was rarely in a straight line, but instead became much twisted and contorted during the early part of its growth. Afterwards it expanded into a swollen tip as at *e*, where there is a strong tendency to fork at its enlarged extremity. To the left of *e* is a tube which makes a sharp twist near the middle and afterwards swells into an Indian-club-like tip.

The coloring substances which proved the best for the study of the nuclei were eosin and azo-rubin. The latter is by far the best of all substances used for the demonstration of the nuclei. Nearly all of the tubes showing three nuclei, as given in the plate, were treated with azo-rubin. No nuclei are shown in some of the tubes, and these, as at *e* and *t*, were drawn from eosin-prepared specimens. The aceto-methl green recommended by Dr. Strasburger proved of very little service in comparison with azo-rubin. This latter substance almost instantly developed a deep blood-red color in the nucleus, while the remaining portion of the protoplasm was left of a lighter hue.

Observations were repeated from day to day with fresh specimens dipped from the culture dish, and the presence of the three nuclei was demonstrated in hundreds of cases. In fact in nearly all long tubes the three blood-red bodies would appear

upon the application of the coloring reagent. In many instances the three nearly equal sized bodies were found after all else in the tube had disappeared.

The attention of teachers who give laboratory instruction is called to the exceedingly easy way in which an unlimited supply of material was provided for this study. A thoroughly cleaned porcelain dish three inches in diameter and a quarter of an inch deep received an ounce of ten per cent. sugar solution, and into this a large quantity of the pollen was dusted from the flowers. A second dish was placed over the first so as to prevent evaporation and the ingress of mould germs. The nourishing solution was kept in a warm room, for it was yet cold out of doors and snow covered the ground. New pollen was dusted into the syrup from day to day so that all stages of the tubes might be obtained at any time. A preparation for the microscope was made by simply dipping out a drop of the syrup on the cleaned tip of a scalpel and placing it upon a glass slide. Fully a week elapsed before moulds began to interfere with the culture. Even after the fungus filaments were producing an entangled mass the pollen and their tubes could be easily determined by the addition of the azo-rubin. This substance did not affect the mould unless very strong, while it almost instantly colored all the protoplasm of the pollen grains and of their tubes.

Dr. Goodale[1] speaks of only two nuclei, one of which is usually larger than the other. Professor Coulter in his paper[2] shows only two. In like manner Professor Barnes[3] demonstrates but two nuclei. Strasburger describes and figures pollen grains with three nuclei in his *Neue Untersuchungen*. With the case in hand the nuclei are all of nearly equal size. As a rule they pass out into the tube early in its development, and generally may be found in the lower half, if not within the club-shaped extremity. When only two nuclei were found in a grain or its tube, one was frequently larger than the other. This fact has led to the suggestion that the larger or vegetative nucleus may un-

1. Goodale's Physiological Botany, p. 428,
2. Pollen spores of Tradescantia. Botanical Gazette, xi, p. 10,
3. Process of Fertilization in Companula Americana. Botonical Gazette, x, p. 349.

dergo a process of division early in the developement of the pollen grain. In some of the immature grains only two nuclei were observed, and these seemed to be united by their slender tips, as indicated above (*c*) in the plate.

In closing, the attention of teachers of physiological botany is again called to the very easy manner in which a large supply of germinated pollen was provided for the study here outlined. The same method has proved successful in several other cultures.

GERMINATION OF ERGOT OF WILD BARLEY.

Last year report was made in the Bulletin, (page 19) of the successful culture of the ergot of wild rye, (Elymus Canadensis, L.). By the same method, the ergot of the wild barley or squirrel-tailed grass (Hordeum jubatum, L.), has been watched this season through the development of the ascigerous heads and the spores which they contain. The ergot of the wild rye required two full months for its growth, while that of the hordeum came to maturity after being in the moist, warm earth six weeks. It is doubtless true that the large grains of the elymus ergot need more time to soften; just as large seeds are often slower in germination than smaller ones, especially if they are of a dry, horny nature, as is the case with mature ergot grains.

All parts of the fruiting stems which grow from the hordeum ergot are smaller than in the elymus fungus, excepting that the stipes are longer. The spore-sacs (asci), however, are somewhat larger, being 150–175 *u* long and 5–7 *u* broad, while the spores have about the same dimensions on the two hosts, namely: 1 by 120 *u*, and sharp pointed and colorless.

If the ergot of wild rye is Claviceps purpurea, Tul. it is probable that this is the same; good allowance, however, being made for differences due to hosts—a factor which is too frequently overlooked in the classification of parasitic fungi.

Ergot has been unusually scarce this season; in fact none was found anywhere in the vicinity of the College, while the year before it was gathered upon timothy as well as upon other grasses than those named above. The dry weather does not seem favorable to ergot development.

RELATION OF RUSTS OF JUNEBERRY AND DWARF JUNIPER.

In the Bulletin for last year (pages 59 64) considerable space was devoted to the results of culture of the cedar apple fungus (Gymnosporangium macropus, Lk.) upon the leaves of the wild crab apple (Pirus coronaria, L.), producing thereby the rust which has received the name of Rœstelia pyrita, Schw. During the past season trials have been made with another species of the same genus, namely, Gymnosporangium claviæforme, DC., which has not been found in Iowa, but grows abundantly in the Eastern States upon the common low juniper, (Juniperus communis, L.) and was kindly sent for trial by Prof. A. B. Seymore, of Cambridge, Mass.

Soon after being received, the affected branches of the cedar were placed under a bell-jar in the laboratory and kept moist and warm until the spores in each gelatinous "horn" germinated and produced multitudes of sporidia. This required only twenty-four hours, and on May 7th sowings of the sporidia were made upon ten clusters of leaves of the cultivated apple, the same number of the wild crab, the juneberry (amelanchier), hawthorn, and mountain ash. The sowings were made in the same manner as previously outlined for those of the native cedar-apple culture of the year before. After a few days the sacs were removed from the clusters of leaves receiving the fungus spores and pinned near by as a guide for future inspection.

On May 23d the cultures upon the juneberry were found successful; that is, the leaves in nearly every case exhibited swollen yellow spots which a few days later developed the characteristic spermagonia that accompany the early stages of the development of a rœstelia cluster. Unfortunately some of the juneberry sowings were upon trees standing in a row of currant bushes, and in the midst of the development of the rust they were all cleared away by the gardeners. However, the sowings upon some choice imported stock of Amelanchier Botryapium, Willd. in the nursery rows were undisturbed. Upon the leaves of this juneberry the rust passed through the

whole course of its development and specimens of the inoculated rœstelia have been preserved.

A careful comparison of these clusters of rœstelia with the descriptions given of the members of the genus by Dr. Farlow and Dr. Winter and with the herbarium specimens and those in Ellis' North American Fungi, indicates that the rust in hand agrees most closely with Rœstelia Botryapites, Schw. These results do not correspond with those of Mr. Thaxter, who concluded from his experiments of last year that Rœstelia Botryapites, Schw. was associated with Gymonosporangium biseptatum, Ellis, and that our Gymnosposangium claviæforme, DC. has Rœstelia lacerata, Fr. as its cluster-cups state.

One thing is, however, certain, namely: the importance of further experimentation along this line. As far as observations have extended there is only one species of gymnosporangium native to this region, or at least at present flourishing here, namely, G. macropus, Lk. If botanists living where other species abound will send fresh material, their spores can be sown upon a wide range of pomaceous plants native and introduced here.

It is only proper to add that none of the other sowings of G. claviæforme, DC. produced any change upon the treated leaves. With so few data it is not wise to make any sweeping statements, but the results so far as they go all point in one direction. The cultivated apple, wild crab, hawthorns, of which three species were tested, and the mountain ash, were all free from any influence. It is hoped that these experiments may be repeated the coming year, and parallel ones with other species of the gymnosporangia.

During the present season cultural experiments with the native cedar apple have been carried out by special students. It is an easy matter to inoculate the wild crab with this, but only failures have attended tests upon other plants.

Several attempts have been made to cultivate the rœstelia back upon the cedar, but without success. This work was, very likely, materially interfered with by the prolonged drought

which visited the region for nearly the whole of the growing season.

There were two distinct crops of the rœstelia upon the wild crab, as the result of natural sowings. One was mature on July 20th, while the second showed only spermagonia on July 27th, and had ripe spores on August 7th. By referring to the record of rainfall (page 13) it will be seen that there were practically two rains, namely: of April 22–23 of 1.26 inch, and of June 12–13 of 1.59 inch, leaving only .86 inch distributed among the other seven small showers from April 21st to June 11th. This covers the period when inoculation probably may take place between the spores of the cedar apple and the leaves of the wild crab. The sporidia which developed shortly after the rains of April 22–23 grew and produced the cups that matured their spores by July 20th. This was a period of fifty-eight (58) days, while the second natural sowing ran the course of development in fifty-five (55) days. More difference might have been expected in favor of the later crop because the weather was so much warmer and stimulating, but it must be remembered that the leaf tissues were getting more firm and probably the conditions for growth in that respect were not so favorable. It should be stated that these observations are upon leaves having the two crops and not upon different leaves, which might vary as to ages.

By referring to the experiments of the previous year it is seen that the artificial culture, with sporidia developed in the warm laboratory were made as early as April 23d, and that the mature rœstelia were recorded for August 7th. This gives a total of one hundred and six (106) days. The only advantage of such early sowing is in avoiding the danger of the tested leaves being inoculated by natural agencies. By taking it a little out of season control is certain.

NOTES UPON THE USTILAGINEÆ.

The Entyloma linearіæ, Schw., which was exceedingly abundant upon Veronica peregrina, L, in 1885 and less common the following season has been comparatively rare the past year. This may be in part due to the dwarfed growth of the host oc-

casioned by the dryness of the season. Ordinarily this entyloma is the most common species of the group.

In striking contrast with this is the Entyloma Menispermi, Far. and Tre. on Menispermum Canadense, L. In the past three years there has been nothing like the present abundance of this fungus. It was no unusual thing to find every leaf of the infested moonseed almost entirely covered with a rank growth of the parasite. The host is common among the undergrowths upon the woody hillsides along the borders of streams. It is not easy to associate the unusual prevalence with increase, but rather with diminuation, in the amount of moisture. All the other species of entyloma were rare this season.

Of the true smuts, that upon the corn, namely, Ustilago Zeæ-mays, Wint., was the most abundant. Careful observations were made upon this species during the past two seasons. In 1886 the per cent. of smutted stocks was 0.4, and of affected ears 0.62. This season there was three times as much of the ustilago. It was so abundant that inquiries came in from various parts of the state as to its injurious nature if fed in quantity to live stock. In short, 1887 is set down among the farmers as a "smut year." In some places every stalk was affected, and frequently these bore the smut in many places, as in the ear, tassel and upon the joints of the stem and midrib of the leaf. As an indication of the prevalence of the smut it may be said that in our farm department extended experiments were carried out in feeding steers upon rations made up of a definite large per centage of these diseased parts of the corn.

The Ustilago syntherismæ, Schw., was particularly fatal to some specimens of the bur-grass (Cenchrus tribuloides, L.) and for this every farmer can only be thankful. There is no more dreaded weed that establishes itself in every dry waste place than this hedge-hog grass, and it is quite sure to find its way into any neglected grain or stubble field. Its home seems to be in the dry sand along the shore of fresh water lakes, and therefore a rainless season is not unfavorable to its development.

Some of the other hosts for members of the genus ustilago

are moisture loving. Thus the U. utricolosa, Nees., grows upon several species of smart weed, especially Polygonum incarnatum, Ell., in this vicinity. In the wet ditches it was not difficult to find large specimens of this smut. The fungus was in average abundance. The same may be said of Ustilago neglecta, Nees, on Setaria glauca, Beauv. Ustilago Rabenhostiana, Kuhn, Ustilago caricis, Pers., Ustilago junci, Schw., and Ustilago segetum, Bull. The last is the species infesting the grain of wheat, barley, oats and a number of grasses. The Ustilago Rabenhorstiana, Kuhn on panic grass was abundant along lanes where the host was growing in dry hard soil.

The species of Urocystis were not noticeably different in abundance from former years. The most common one was U. anemones, Pers., upon Anemone acutiloba, Law.

The observations of the past two years, although insufficient to warrant any conclusion, lead to the tentative opinion that smuts are not influenced by rainy weather to the same degree that seems to be true of the downy mildews (Peronosporeæ). If any general statement may be made it is to the effect that upon hosts which are most influenced by drought, the smut is increased in a dry season. This is very likely due to the fungus having a weakened subject upon which to feed and its inroads are more certain to produce striking results. If a resisting power is granted to a healthy plant, it follows that the drought weakens the host somewhat, and the parasite is thereby enabled to run its course with greater freedom. In this sense it might be said that dry weather favors the development of smut. That it facilitates the spread of the disease from an already infested plant is another question not here to be considered.

It should be added that a member of the group preying upon insects namely the fly fungus (Entomophthora muscæ, Cohn.) has been far less abundant the past year than in 1886. Housekeepers are united in the complaint that flies are much more numerous this season than last. It may be that in this instance the vigor of the insect is the cause of the difference due to the absence of the fungus. The result whether from one or both of these causes was evident to all observing persons.

TRIPLE-CELLED TELEUTOSPORES OF PUCCINIA TANACETI, DC.

The engraving figure 5 shows interesting triple-spored forms of teleutospores of the Puccinia Tanaciti, DC. grown upon Helcanthus grosse-serratus, Mart. At *a* is the normal form of the spore with an additional middle cell; a much elongated form is seen at *c*. The figure *b* illustrates a second type in which two cells are wedged together and occupy the upper part of the spore. Much the same condition of the cells is shown at *d*, the third cell being mostly on the rear side. These tripple spores were not at all rare with this species on this host. Search was made for them on other hosts but without success.

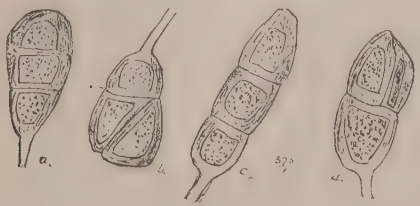

FIG. 5.

TRIPPLE-CELLED TELEUTOSPORES OF PUCCINIA TANACETI.

DOWNY MILDEWS IN A DRY SEASON.

As noted elsewhere (page 13) the past two years have been remarkable for a prolonged drought in Iowa and the prairie region. The following observations made upon the group Peronosporeæ during this time may therefore be of interest, and for convenience the species are treated in the order they are given in Dr. Farlow's "Enumeration of the Peronosporeæ of the United States."

PHYTOPHTHORA INFESTANS, D. By.—Two years ago after an average season, there was much complaint of the rot in all parts of the State and tubers from the college gardens and root houses contained the parasite in abundance. The potato crop for the present year (1887) has been very light and no rot was observed.

Peronospora viticola, D. By.—None of this mildew of the grape has been found the present year, although the search for it was frequently made, and in places where two years before the wild canes of Vitis riparia, Michx. were dwarfed and covered with a thick white felt down to the earth's surface. No signs of the mildew could be found in the larger college vineyard where many sorts of cultivated grapes and a few scattered vines of native wild species are grown. The vines were in every way healthy and flourished when all about them was suffering with the drought and heat.

Peronospora Halstedii, Farlow, is the most wide spread species of this locality. Its hosts are numerous, the leading ones of which are several species of Helianthus, Silphium, Eupatorium, Bidens and a long list of other genera all of the order Compositæ. Last season Helianthus grosse-serratus, Mart., was added to the host list and this year Bidens connata var comosa, Gray, was found badly infested. Last year this mildew was moderately common, but in 1887 it has been found growing upon those composites which thrive in wet places. It has been rare upon Helianthus, not found at all upon Ambrosia artemesiæfolia, L. Solidago Canadensis, L. or Eupatorium and Silphium species. In short the genus Bidens has been the only one which could furnish any considerable supply of specimens. B. frondosa, L. B. chrysanthemoides, Michx. and B. connata var. above noted, all were infested and such species grow in beds of streams where plenty of moisture reached the rank succulent plants.

Peronospora obducens, Sch. upon Impatiens fulva, Nutt. although common in ordinary seasons has not been met with during the last year. The host is not uncommon in wet places but such situations have been rare of late.

Peronospora Geranii, Pk., has not been found this year upon the common host Geranium maculatum, L. but in May was collected by A. S. Hitchcock, upon Geranium Carolinianum, L. at Iowa City, and thus adds another host to the list for the State. It was not at all abundant.

Peronospora pygmæa, Unger, on anemone species has not been observed this year.

Peronospora gangliforms, D. By. was "shy," as the horticulturists say; occasionally it appeared upon the lower leaves of Mulgedium leucophæum, DC. The Nabalus albus, Hook, and Lactuca hosts prefer dry ground and in their dwarfed condition have been spared from inroads from the mildew.

Peronospora parasitica, Tul., is one of our most common species upon various cruciferous hosts. In ordinary seasons Lepidium Virginicum, L. is badly infested, having its branches strangely distorted. This year the pepper grass has been quite free from this parasite, if we except the seedlings which for a few weeks in spring were attacked. The mildew passes the winter within the tissue of these seedling plants and sometimes oospores may be found there. As the warm spring weather comes, the fungus is quickened into new life and soon develops conidia which aid in the rapid spread of the mildew. During the present year this peronospora has been most abundant upon Nasturtium palustre, DC. In June the lower leaves of this host, lying close to the moist ground of borders of streams were quite generally affected. A little later when the drought had progressed it was not abundant. In some specimens the conidiophores were not more than one fourth the normal size. Other parts of the same patch showed all gradations and it may be observed that conditions may dwarf the parasite as well as the host.

Peronospora Potentillæ, D. By., was common on Potentilla Novegica, L., early in the season, when the host was growing on the borders of low wet places. It disappeared as the dry weather of late spring arrived.

Peronospora Claytoneæ, Farlow, has not been found in Iowa but was abundant in southern California (Santa Barbara) where during the last winter (86-7) the writer found it on the leaves of Claytonia perfoliata, 00, but only when the host was growing luxuriantly in damp shady places. It is a new host for this comparatively new species of Peronospora. What is supposed to be the same species, although no oospores were found, was collected upon Calandrinia Menziesii, Hook. In this instance the mildew was growing upon plants in open, dusty

stubble fields. It must, however, be remembered that this Calandrinia is a near relative of the common purslane of the East, and, like it, is a low succulent plant which is bathed by the heavy dews and in itself retains a large amount of water. Although the host thrives in the dust the parasite is not, therefore, a lover of dryness. It was also observed that the fungus thrives best upon luxuriant plants which were well watered and shaded.

Peronospora Arthuri, Farlow, was not uncommon two years ago, but the past season it has been found only on a few plants growing along the shady bank of a stream. The year before it was abundant and the writer collected it at Manitou, Colorado. The single infested plant was, however, in Englemann's Canon and where the bright sun rarely reached it.

Peronospora effusa, Rabh., is a common species upon Chenopodium album, L., but has been far less abundant than usual this year.

Peronospora Polygoni, Thum., is rare on Polygonum dumetorum, L. Mr. Hitchcock found this mildew upon P. aviculare, L. at Iowa City, in May of the present year, but it was not at all common. This adds a new host for America.

Peronospora alta, Fcl., has been almost entirely absent from Plantago major, L. for the last year. In 1885 it was one of the easiest of the peronosporas for the students to collect.

Peronospora Trifoliorum, D. By., has heretofore been one of our most common species upon Astragalus Canadensis, L. and especially on Vicia Americana, Muhl. Upon the latter two years ago it was so abundant as to almost destroy the host in whole patches. It has been found the past year only after diligent search in the moistest places where the vetch will grow.

Peronospora Euphorbiæ, Fcl., is a species which quickly disappears in times of drought. It is not uncommon on Euphorbia maculata, L. in a wet season, but was rare indeed the past year. A new host E. serpyllifolia, Pers., was added for this mildew by Mr. Hitchcock, who found it at Jewel Junction.

Peronospora leptosperma, D. By., was common in 1885 on both Artemesia biennis, Willd. and A, Ludoviciana, Nutt. During the past season it has been met with in only a few places on A. biennis, Willd. growing in moist spots near excavations along a railroad track.

Peronospora sordida, Berk., is a good illustration of the influence of moisture upon the development of peronosporæ. The host, Scrophularia nodosa, L., is a common plant on the banks of streams, especially where the surface is without sod. During the past year the mildew was often looked for and found in its usual abundance in only one place. This was in a bend of a stream where the host grew close to the water and could only be reached by wading.

Peronospora Lophanthi, Farlow, on Lophanthus scrophulariæfolius, Benth., is a rare species with us and was not found at the College before the present year.

Peronospora graminicola, Schrt., which was abundant last year upon Setaria viridis, Beauv., transforming the inflorescence of the grass into strange shapes, has been far less abundant during the season just closed. Not more than a tenth as much could be found this year upon the same area kept under the same culture as last season, namely: a small cherry orchard on plowed but uncropped land. However, it was discovered this season to some extent upon the Hungarian grass where it produced the same distortions of leaf and flower as upon the foxtail. It is not known what this mildew may do on a damp year, but the probabilities are that this species, now comparatively new to America, may prove a serious hindrance to the growth of one of our leading forage crops.

Peronospora Calotheca, D. By., is not rare upon species of galium. On October 14th, seedling plants which had come up in a rich mould since the September rains were badly infested. This is a good illustration of fresh growing tissue being favorable for the development of peronosporæ.

The genus Cystopus has four species common to the state.

Cystopus candidus, Lev., like Peronospora parasitica is confined to the cruciferæ and also like it, lives over the winter

within the tissue of seedling plants. This has been observed in particular with the shepherd's purse (Capsella bursa-pastoris, Mœnch). The white mildew appears early in the spring and grows with the host through the summer. In autumn it again makes its appearance upon the seedling plants and remains here until the following spring. This fact may account for the absence of oospores in the host, as they are not essential for the continuation of the fungus from one year to another. Last spring there was an abundance of the cystopus on shepherd's purse seedlings and produced a large crop of spores which did not spread the trouble rapidly to other plants as on an ordinary season. In June there was very little of the mildew and only a few spots could be seen on the seedlings the past autumn. A small amount of the fungus is to be predicted for the next spring. The mildew was fairly abundant upon the common pepper grass (Lepidium Virginicum, L.) last spring but soon disappeared. Two years ago in a moist season the blossoms, flower-stalks and seed vessels of the garden radish were generally attacked and often distorted beyond recognition, but none of this distructive work was done the past year. Very late in October the mildew was found prevalent upon seedling plants of Sisymbrium officinale, Scop., which had developed after the September rains in a shady place. From such infested plants will proceed the spores that spread the mildew over large areas.

Cystopus cubicus, Lev., is the least common species of the genus and for the last two years has been comparatively unknown here. At rare intervals it is found upon Ambrosia artemesiacfolia, C.

Cystopus Bliti, Lev., occurs upon an increasing list of hosts. Up to the present year it was known in the United States upon Amarantus hybridus, L. A. retroflexus, L.; A. blitoides, Watson, and Acnida cannabina, L. The additional hosts for this country for 1887 are Amarantus albus L., and Acnida tamariscina, Gray. Upon both these hosts the mildew was far from rare. The acnida grows only in low moist places and what effect a wet season may have upon it is undetermined.

Amarantus blitoides was badly infested and as this species flourishes in dry places, upon paths and roadways it at first seems an exception to the rule. However this amaranth is thick-leaved and succulent and like the purslane is itself full of moisture even though the surroundings are arid. It is a fact of observation that the greatest development of the mildew was upon plants which were most favored with moisture and shade.

Cystopus Portulacæ, Lev., is the last species of the list and one of no little interest in the present connection. It seems to have been more adundant during the past two dry seasons than before. As before stated the host is a juicy plant and the appearance of greater thrift on the part of the parasite may be due to the fact that it was more than usually destructive, the purslane not being able to withstand its attacks. Therefore a patch of the host while showing more of destructive effects of the mildew might in fact have less of the parasite. In other words it is easy to see that less of the fungus might, under unfavorable circumstances for the host, make a worse appearance. A dry season favors the dispersion of the spores, which, dust-like, float through the air. The purslane being low protits by all the dews and the mildew spores are also thereby furnished the conditions for germination. There seems to be a provision for the dispersion of the spores which may be more than accidental. The stems when badly infested become upright and rigid, and these vertical branches when hit by passing feet of animals scatter their spores over wide areas. It is not uncommon to see three or four badly mildewed stems standing upright while the more healthy portion of a plant observes the prostrate habit of growth.

To return now to the general subject it seems to us that these observed facts show that with the Peronosporeæ there is no doubt that the species are best suited to a moist season. The members of the genus Peronospora have in no instance been so abundant during the last two dry years as before the drought came. There was a decided decrease of the mildews the past year until the September rains came, and after that a few weeks of warm weather followed, during which seedlings of various

kinds sprang up and on these, in some instances, peronosporæ made their appearance. In general the mildews were found in early spring, after this, through the long dry summer, in limited quantities, upon plants growing in moist places along streams and edges of pools.

The genus Cystopus seems less influenced by drought, but as a rule there was less of the species and the infested specimens were those best situated for obtaining moisture. In all cases where peronosporeæ flourished they were upon succulent hosts and even with these there was probably less growth of parasite but a greater manifestation of disease due to lack of vitality in the hosts. These instances therefore form no exception to the general rule, that dry weather is not advantageous for the development of the Peronosporeæ.

PROVISIONAL LIST OF PROVISIONAL SPECIES OF FUNGI.

During the past summer Mr A. S. Hitchcock, M. S., an assistant in the State University at Iowa City, spent several weeks of his vacation in the botanical laboratory studying the fungi of the great groups Pyrenomycetes and Hyphomycetes, and especially their imperfect forms. As no record has been made for the State of the provisional species of these groups, the following list is appended:

1. *Cercospora Ampelopsidis*, Pk.
   On Ampelopsis quinquifolia, Mich. (1748.)
2. *Cercespora anomala*, Ellis & Halsted.
   Hypophyllous forming indefinite patches, olivaceous at first becoming black. The leaf also shows finally sub-indefinite blackish-brown spots above. The erect fertile hyphæ 30–50x4–5 *u*, pale olevaceous, arise from prostrate sub-hyaline or pale olevaceous branching, septate threads and bear at their tips the oblong cylindrical smoky-hyaline 20–40x45 *u* conidia.

   This has the general aspect of C. Helianthi, E. & E., but the hyphæ and conidia are quite different and the species va-

ries from the ordinary type of cercospora approaching cladosporium. On living leaves of Actinomeris squarrosa, Nutt. Ames, Iowa, August, 1887.

3. *Cercospora Apocini*, E. & K.
On Apocynum androsæmifolium, L. (1512.)

4. *Cercospora avicularis*, Wint.
On Polygonum erectum, Roth.

5. *Cercospora Catalpæ*, Wint.
On Catalpa speciosa, Ward.

6. *Cercospora circumcissa*, Sacc.
On cultivated cherry. (646.)

7. *Cercospora Chenopodii*, Fries.
On Chenopodium album, L. (550).

8. *Cercospora effusa*, B. & C.
On Lobelia syphilitica L, (1516.)

9. *Cercospora Gymnocladi*, E. & K.
On Gymnocladi Canadensis, Lam. (1511).

10. *Cercospora Helianthi*, E. & E.
On Helianthus doronicoides, Lam.

11. *Cercospora Heucheræ*, E. & M.
On Heuchera hispida, Pursh. (1258.)

12. *Cercospora lateritia*, Ellis & Halsted.
Hypophyllous in indefinite pale brick-colored patches, which soon become confluent, covering the greater part of the lower surface of the leaf, which is variegated above with brownish spots becoming dark and finally nearly black. Hyphæ coarse 50–70x8–10 *u*, branching and septate, arising in sparing tufts through the stomata of the leaf and more or less interwoven and matted together, conidia mostly cylindrical and straight with ends obtuse, 2–6 septate and generally constricted at the septa, reddish-brown 50–80x6–8 *u*, occasionally larger (100 *u* or over) and then attenuated above.
This species is closely allied to C. ferruginea, Fcl. and C. racemosa, E. & M., but is a coarser species than either of these, though in color and general appearance it much resembles the latter.—On living leaves of Sambucus racemosa, L. Ames, Iowa, September, 1887. (1994).

13. *Cercospora Lycii*, Ellis & Halsted.
Spots amphigenous yellowish-brown becoming thin and white in the center. 2–4 m. m. in diameter, discoid with a definite raised margin. Hyphæ mostly epiphyllous, yellowish-brown, paler above, septate, 80—120x4 *u*, nearly straight but more or less shouldered and toothed above, forming erect tufts arising from a small turbercular base. Condia slender 80–150x about 4 *u*, hyaline continuous or faintly 3–4 or more septate.
On leaves of Lycium vulgare, L.—Ames, Iowa, September, 1887.

14. *Cercospora Menispermi*, Ell. & Hol.
On Menispermum Canadense, L.

15. *Cercospora microsora*, Sacc.
On Tilea, sp. cult. (1520.)

16. *Cercospora moricola*, Cke.
On Morus rubra, L.

17. *Cercospora Oxybaphi*, Ellis & Halsted.
Amphigenous forming rusty brown indefinite spots which are more conspicuous on upper side of leaf. Hyphæ pale, short—25 -30x3 *u* and crooked, sparingly septate, mostly issuing from the stomata in very minute black, sparing tufts, with a coarsely cellular base. These tufts appear in indefinitely limited groups and are so minute as to be barely visible under the lens; conidia filiform obclavate 3–4 -septate, hyaline 30–50x3 *u*.
On leaves of Oxybaphus nyctagineus, Sweet.—Iowa City, June, 1887, collected by A. S. Hitchcock.

18. *Cercospora Physalidis*, Ell.
On Physalis pubescens, L.

19. *Cercospora Ptelea*, Wint.
On Ptelea trifoliata, L.

20. *Cercospora Pyri*, Farl.
On cultivated apple. It differs from the type in the character of the spot which in this is large reddish-brown. The small, central ashy area is bordered by a dark ring.

21. *Cercospora racemosa*, E. & M.

On Teucrium Canadense, L. (1504.)

22. *Cercospora reticulata*, Pk.
On Solidago latifolia, L.

23. *Cercospora, rhuina*, C. & E.
On Rhus glabra, L. (1252.)

24. *Cercospora rosæcola*, Sacc.
On cultivated roses. (1255.)

25. *Cercospora sedoides*, E. & E.
On Penthorum sedoides, L.

26. *Cercospora Spegazzinii*, Sacc.
On Celtis occidentalis, L.

27. *Cercospora squalida*, Peak.
On Clematis Virginiana, L. (1522).

28. *Cercospora superflua*, E. & Hol.
On Fraxinus.

29. *Cercospora Teucrii*, E. & H.
On Teucrium Canadense, L. (1506.)

30. *Cercospora tabacina*, E. & E.
On Rudbeckia triloba, L.

31. *Cercospora umbrata*, E. & H.
On Bidens frondosa, L. & B. chrysantemoides, Michx. (1521).

32. *Cercospora variicolor*, Wint.
On Pæonia.

33. *Cercospora Vernoniæ*, E. & K.
On Vernonia fasciculata, Michx.

34. *Ramularia Armoracea*, Fckl.
On Nasturtium armoracia, Fries. and N. palustre, DC.

35. *Ramularia arvensis*, Sacc.
On Potentilla Norvegica, L. (1240).

36. *Ramularia cana*, Sacc.
On Erigeron Canadense, L.

37. *Ramularia Celastri*, E. & M.
On Celastrus scandens, L. (1238).

38. *Ramularia decepiens.*
On Rumex crispus, L. and R. verticillatus, L.

39. *Ramularia gibba*, Fckl.
On Ranunculus repens, L. (1983).

40. *Ramularia macrospora.* Fr. var. *asteris*, Trc.
On Aster Novæ-Angliæ, L.

41. *Ramularia Plantaginis*, E. & M.
On Plantago major, L. (1243).

42. *Ramularia pratensis*, Sacc.
On Rumex Britannica, L.

43. *Ramularia Ranunculi*, Pk.
On Ranunculus abortivus, L.

44. *Ramularia rufomaculans*, Pk.
On Polygonum dumetorum, L.

45. *Ramularia Taraxaci*, Karst.
On Taraxacum officinale, Weber.

46. *Ramularia Tulasnei*, Sacc.
On cultivated and wild strawberry. (1239).

47. *Ramularia variabilis*, Fckl.
On Verbascum Thapsus, L. (1530).

48. *Didymaria Ungeri*, Corda.
On Anemone cylindrica, Gray.

49. *Heterosporium gracile*, Wallr.
On Pardanthus Chinensis, Ker.

50. *Cylindrosporium Iridis*, Ellis & Halsted.
Acervuli very minute and numerous, subcuticular, blackish forming continuous series of stripes between the parallel nerves of the leaf for several cms. in length. The exuded spores appear like a thin white tomentum on the matrix; spores acicular, continuous, hyaline, 15–22x1 *u*. Hyphæ short 8–10x2 *u*, obscure, mostly toothed above.
On living leaves of Iris versicolor, L.—Iowa City, June, 1887. Collected by A. S. Hitchcock.

51. *Microstroma Juglandis*, Sacc.
On Juglans nigra, L.

52. *Phoma Virginiana*, Ellis & Halsted.
Spots amphigenous, large ($\frac{1}{2}$–1cm.) round sub-indefinite, rusty-brown above, darker below; perithecia hypophyllous, minute abundant, erumpent—superficial; sporules oblong-cylindrical. 5–7x1$\frac{1}{2}$*u*.
On Prunus Virginiana, L.—Ames, Iowa, September, 1879.

53. *Phyllosticta abortiva*, E. & K.
On Menispermum Canadense, L.
54. *Phyllosticata Ampelopsidis*, E. & M.
On Ampelopsis quinquefolia, Michx, (1169).
55. *Phyllosticta argyrea*, Speg.
On Elæagnus longifolius, Pers.
56. *Phyllosticta gentianicola*, DC.
On Gentiana alba, Muhl.
57. *Phyllosticta phaseolina*, Sacc.
On Phaseolus diversifolia, Pers.
58. *Phyllosticta phomiformis*, Saac.
On Quercus alba, L. (1160).
59. *Phyllosticta sphæropsoidæ*, E. & E.
On Æsculus flava, cult. (1159).
60. *Phyllosticta Teucrii*, Sacc.
61. *Phyllosticta Violæ*, Dem.
On Viola pubescens, Ait.
62. *Phyllosticta viticola*, Thum.
On Vitis riparia, Michx.
63. *Phyllosticta*, sp.
On Ludwigia polycarpa, S. & P. A few specimens of an unrecorded species and not sufficient for description.
64. *Septoria aceris*, B. & Br.
On Negundo aceroides, Mœnch. (346.)
65. *Septoria argyraæ*, Sacc.
On Elæagnus angustifolia. (1967).
66. *Septoria atropurpurea*, Pk.
On Aster Novæ-Angliæ, L.
67. *Septoria Cacaliæ*, E. & K.
On Cacalea atriplicifolia, L. (1132.)
68. *Septoria Campanulæ*, Lev.
On Campanula Americana, L. (1616).
69. *Septoria Cannabina*, West.
On Cannabis sativa, L. (1744.)
70. *Septoria Celtis-galtæ*, Geno.
On Celtis occidentalis, L.
71. *Septoria Cirsii*, Nees.

On Cnicus altissimus, Willd. (1729.)

72. *Septoria conspicua*, E. & M.
On Steironema ciliatum, Raf. (1736).

73. *Septoria cornicola*, Desm.
On Cornus asperifolia, Mchx and C., paniculata, L. Her.

74. *Septoria Corylina*, Pk.
On Corylus rostrata, Ait.

75. *Septoria Erigeronitis*, Pk.
On Erigeron strigosum, Muhl. (1129).

76. *Septoria Eupatorii*, Rab. and Desm.
On Eupatorium ageratoides, L.

77. *Septoria Helianthi*, E. & K.
On Helianthus strumosus, L. (1134).

78. *Septoria Leptostachya*, E. & K.
On Phryma Leptostachya, L.

79. *Septoria Lobeleæ*, Pk.
On Lobelia syphilitica, L.

80. *Septoria microsperma*, Pk.
On Betula.

81. *Septoria Mimuli*, E. & K.
On Minulus ringens, L. (1738).

82. *Septoria Nabali*, B. & C.
On Prenanthes racemosa, Michx.

83. *Septoria Œnothera*, West.
On Œnothera biennis, (38) L.

84. *Septoria Pileæ*, Thum.
On Pilea pumula, Gray.

85. *Septoria platanifolia*, Cke.
On Platanus occidentalis, L.

86. *Septoria Pyri*, Cast.
On Pirus Malus, L. and P. coronaria, L.

87. *Septoria Querceti*, Thum.
On Quercus rubra, L.

88. *Septoria Rhaponticæ*, Thum.
On Rheum Rhaponticum, L.

89. *Septoria Ribis*, Desm.
On cultivated gooseberry. (1148.)

90. *Septoria Rubi*, West.
On Rubus odoratus, L.

91. *Septoria Rudbeckiæ*, Ellis and Halsted.
Spots conspicuous, medium size, outline irregular, angular distinct; border purplish, area brown, often with one or more white or ashy angular spots. Perithecia epiphyllous, dark, few, large (80–120 *u.*) much scattered. Sporules hyaline fusiform (2 3x40–60 *u.*) multisplate. On leaves of Rudbeckia, triloba L, and R, laciniata, L. Ames, Iowa, August, 1887.

92. *Septoria sambucina*, Pk.
On Sambucus racemosa, L.

93. *Septoria Sicyi*, Pk.
On Echinocystis lobata, T. & G.

94. *Septoria Smilacina*, D. & M.
On Smilax herbacea, L.

95. *Septoria Smilacinæ*, E. & M.
On Smilacina racemosa, Desf. (1146.)

96. *Septoria Solidaginis*, Thum.
On Solidago Canadensis, L.

97. *Septoria Specularіæ* B. & C.
On Specularia perfoliata, A. DC., (1971).

98. *Septoria Sphærelloides*, E. & K.
On Hypericum mutilum, L.

99. *Septoria Toxicodendri*, Curt.
On Rhus Toxicodendron, L.

100. *Septoria Urticæ*, Desm.
On Laportea Canadensis, Gaud.

101. *Septoria Verbenæ*, R & D.
On Verbena urticifolia, L.

102. *Septoria Veronicæ.*
On Veronica Virginica, L.

103. *Septoria Virgaureæ*, Desm.
On Solidago serotina, Ait.

104. *Sphærella Impatientis*, P. & C.
On Impatiens fulva, Nutt.

105. *Piggotia Fraxini.* B. & C.

On Fraxinus viridis, Michx.

106. *Vermicularia sanguinea*, Ellis & Halsted.

Spots amphigenous subelleptical 2–3 m. m. in diameter, at first smaller and purplish-red becoming larger and black and finally white in the center, the leaf remaining permanently stained purplish-red around the spots. Perithecia erumpent, subconcenrically arranged, or irregularly scattered or collected in a compact group in the center of the spot, depressed-globose, open above, beset with straight black continuous or sparingly septate black bristles, 60-90x3–3½ *u*. Conidia broad arcuate-fusoid, more acute and narrower above, hyaline granular and nucleate 20–22x about 6 *u*.

In its mode of growth and other respects apparently distinct from other graminicolous species. On living leaves of some introduced Europen Panicum in test grass plots, Ames, Iowa, Sept. 1887.

107. *Cicinnobolus Cesatii*, D. By.

On Echinospermum Verginicum, Lehm. very abundand and on other hosts with members of Erysipheæ.

HOSTS OF THE IOWA ERYSIPHEÆ.

Acer dasycarpum, Ehrh.
Actinomeris squarrosa, Nutt.
Agrimonia Eupatoria, L.
Ambrosia artemisiæfolia, L.
Ambrosia trifida, L.
Ampelopsis quinquefolia, Michx.
Artemesia Ludoviciana, Nutt.
Artemesia serrata, Nutt.
Aster sp.
Astragalus Canadensis, L.
Bidens cernua, L.
Bidens connata, Muhl.
Bidens chrysanthemoides, Michx.
Bidens frondosa, L.
Catalpa speciosa.
Celtis occidentalis, L.
Clematis Virginiana, L.
Cnicus altissimus, Willd.
Cornus paniculata, L. Her.
Corylus Americana, Walt.
Corylus rostrata, Ait.
Cratægus tomentosa, var punctata, Gray.
Desmodium sessilifolium, T. & G.
Echinospermum Virginicum, L.
Epilobium coloratum, Muhl.
Erechthites hieracifolia, Rab.
Erigeron Canadense, L.
Erigeron Philadelphicum, L.
Erysimum cheiranthoides, L.
Euonymus atropurpureus, Jacq.
Euphrobia corollata, L.
Fraxinus viridis, Michx.
Geranium maculatum, L.
Gerandia tenuifolia, Vahl.
Geum album, Gmelin.
Helianthus doronicoides, Lam.
Helianthus læteflorus, Pers.
Helianthus strumosus, L.
Hydrophyllum Virginicum, L.

Lathyrus palustris, L.
Lonicera Albertii.——?
Lonicera flava, Sims.
Ostrya Virginica, Willd.
Oxalis corniculata, var stricta, Sav.
Poa pratensis, L.
Populus tremuloides, Michx.
Prunus Americana, Marshall.
Prunus Cerasus, L.
Pirus Malus, L.
Quercus rubra, L.
Ranunculus abortivus, L.
Ribes Cynosbati, L.
Ribes rotundifolium, Michx.
Rosa blanda, Ait.
Salix sp.
Scutellaria lateriflora, L.
Solidago Canadensis, L.
Solidago serotina, Ait.
Spiræa salicifolia, L.
Stachys palustris, L.
Symphoricarpus vulgaris, Michx.
Syringa vulgaris, L.
Taraxacum officinale, Web.
Tilia Americana, L.
Ulmus Americana, L.
Ulmus fulva, Michx.
Verbena bracteosá, Michx.
Verbena hastata, L.
Verbena stricta, Vent.
Verbena urticifolia, L.
Vernonia fasciculata, Michx.
Veronica Virginica, L.
Viburnum Lentago, L.
Vitis riparia, Michx.
Xanthium Canadense, L.
Zanthoxylum Americanum, Mill.

COMMON NAMES OF HOSTS OF ERYSEPHEÆ.

Actinomeris.
Agrimony.
American Ivy.
Apple.
Ash.
Aspen.
Avens.
Basswood.
Beggar's lice.
Beggar's-ticks.
Blue grass.
Bur-Marigold.
Burning-bush.
Buttercup.
Catalpa.
Cherry.
Clot-bur.
Cockle-bur.
Cranes-bill.
Crowfoot.
Currant.
Dandelion.
Dogwood.
Elm.
Euphorbia.
Fire-weed.
Fleabane.
Gerardia.
Geranium.
Goldenrod.
Green ash.
Great marigold.
Grape.
Hackberry.
Hawthorn.
Hazelnut.
Hedge-nettle.
Honeysuckle.
Hop-hornbeam.
Horse-weed.
Iron-weed.
Large beggar's-ticks.
Lilac.
Linden.
Maple.
Marsh-vetch.
Mugwort.
Milkweed.
Oak.
Pasture thistle.
Poplar.
Prickly Ash.
Ragweed.
Red-oak.

Rose.
Scull-cap.
Sheep-berry.
Slippery-elm.
Soft maple.
Sorrel.
Spiræa.
Snow-berry.
Sunflower.
Thistle.
Tick-trefoil.
Verbena.
Vervain.
Virginia creeper.
Virgin's bower.
Waahoo.
Water leaf.
Wild cherry.
Wild currant.
Wild grape.
Willow.
Willow-herb.
Wormseed mustard.
Wormwood.

FUNGI COLLECTED FOR DISTRIBUTION.

During the past year, the following leaf-fungi have been collected in quantity for Mr. J. B. Ellis' centuries of the North American Fungi.

Paccinia obtecta, Pk.
On Scripus validus, Vahl.

Puccinia stipæ, Arthur.
On stipa spartea, Trin.

Puccinia Tanaceti, DC.
On Artemesia dracunculoides, Pursh.

Uromyces digitatas, N. sp. (see below.)
On Leersia Virginica, Willd.

Erysiphe Linkii, Lev.
On Artemesia serrata, Nutt.

Peziza Dehnii, Rabh.
On Potentilla Norvegica, L.

Septoria argyraea, Sacc.
On Eleagnus angustifolia.

Ramularia gibba, Fckl.
On Ranunculus repens, L.

Ramularia Armoracea, Fckl.
On Nastartium Armoracea, Fries.

Cercospora sedoides, E. & E.
On Penthorum sedoides, L.

Cercospora lateritia, Ell & Hals.
On Sambucus racemosa, L.

Uromyces digitatus, Halsted.—Sori mostly hypogenous, small, elongated, forming irregular rows; uredospores 22–25x26 *u*, eleptical light-yellow indistinctly echinulate tips black; teleuto-sori shining black, spores wedge-shaped and quite irregular, 17–30x25–33 *u*, pedicel about one-half the length of the spore. The broad free end of the spore is divided into 5 to 20 sharp or blunt projections, the longer with hyaline tips. On leaves of Leersia Virginca, Willd. This new uromyces approaches U. acuminatus, Arth., but differs from it greatly in the wedge, or triangular shape of the teleutospores and the large number of terminations which cover the broad free end. These irregular projections, make the spore like a minute boxing glove; they frequently extend downward along the whole of one side of the spore.

FIG. 6.—Uredo and Teluenospores of Leersia Uromyces.

Figure 6. *a* shows the uredo spore and a number of the variable teleutospores are seen at *b*, *b*.

Of the collections made in California during the winter of 1886-7 the following were sent for the same centuries of fungi.

Peronospora Claytoneæ, Farl.
On Claytonia perfoliata, Donn.
Uromyces Beetæ, Kuhn.
On cult. Beta vulgaris, L.
Æcidium Phaceleæ, Pk.
On Phacelia ramosissima, Doug.
Cercospora ricinella, Sacc.
On Ricinus communis, L.
Cercospora rubigo, C. & H.
On Clematis ligusticifolia, Nutt.

CALIFORNIA PARASITIC FUNGI.

The following fungi were collected in Southern California during the winter of 1886-7.

Peronspora Claytoniæ, Farlow, on Claytonia perfoliata, Donn. The host is a beautiful half-succulent plant growing in moist places and the peronospora causes large brown patches upon the leaves often bordered by a distinct purplish line. Oospores are abundant and may be seen in brown patches through the thin leaf in dried specimens. Probably the same mildew was found infesting the Calandrinia Menziesii, Hook. This host is common upon the hillsides in stubble fields and in the "pursley" of that region. The fungus attacks the whole leaf. No oospores were found after long searching.

Peronospora leptosperma, D. By.

On Artemesia Ludoviciana, Nutt.

Uncinula Salicis, Wint.

On Salix sp. Mature fruit abundant.

Sphærotheca lanestris, Hark.

On Quercus agrifolia, Nees. The condial state is remarkably large and vigorous in habit, distorting the infested young shoots dwarfing the leaves and coating them with a dense white felt-like layer, noticeable for long distances. The perithecia appear upon the under surface of leaves, forming rusty velvety patches.

The conidial forms of other Erysipheæ were found upon Verbena officinalis, L. Lathrus vestitus, Nutt., and undetermined species of gilia, mints, grasses, clover and the cultivated radish.

Uromyces Luaini, B.& C., on Lupinus rivularis, Doug. This rust was abundant in its three forms, but rarely were they associated together upon the same leaf. Certain plants would be found with every part of the foliage occupied by the Æcidium while other plants were covered with the rusty uredo form and others still were spotted with the darker teleutosporis.

Uromyces Betæ, Kuhn, on Beta vulgaris L., in both its cultivated state and as strays in the low ground near vegetable gardens at Santa Barbara. This is a serious rust to the beet and was making much trouble for the market gardeners. In some places every leaf of the plant was badly infested and whole rows of beets were dwarfed and discolored by the parasite. The pest is to be found in its worst form in the escaped plants which in some places almost cover the moist low ground. These places are virtually propagation beds for the rust and the first step in eradication should be the destruction of the wild beets.

Uromyces Juncæ, Desm., on Juncus effusus, L. This was very common.

Uromyces orobi, Pers., on Lathrus venosus, Muhl.

Puccinia galiorum, Lk., galium Sp. The æcidium of this species was very abundant.

Puccinia aruni-spinosæ, Pers., on leaves of cultivated peach and almond. This rust was prevalent at Los Angeles and Santa Barbara and caused the foliage of the trees to become of a sickly color and finally rusty with the multitudes of uredo spores and dark spotted when the telentospores appeared later in the season. Late in November only the uredo could be found but in February the final state was reached. These teleutospores have been compared with those of the same species on Prunus serotina, collected at Newton, Mass., by Dr. Farlow, and from the same host here at Ames. The Californian type is shown at *a* in figure 6. In this the two cells are of nearly equal size, the upper one averaging somewhat larger than the lower and nearly spherical when mature. The two

FIG. 6. SPORES OF PEACH AND ALMOND RUST.

cells readily separate at maturity when a ripe cluster of the spores is placed in a drop of water on a slide for microscopic

study. The prevailing form of the uredo spores is shown at *b*. At *c* is shown and average spore from the Massachusetts specimens; it has an irregular outline, is much broader than the Californian specimens and the two cells are closely joined by a broad face. A nucleus is prominent in each cell as indicated in the engraving. An uredo spore is shown at *d*. It is nearly twice the length of that of the Californian form. An Ames specimen of teleutospere, shown at *e*, is broader and much shorter than those gathered at Newton, Mass. Some of them are distorted, having the stipe near one side and the spore irregularly broader than long. The uredo spore agrees quite closely with the one shown at *d*. When the teleutospores of the Californian specimens are young, the upper cell is much larger than the lower one and its spines appear much sooner. In short the peach and almond rust is a well marked variety if not a distinct species from that upon the Prunus serotina.

Puccinia Menthæ, Pers.

On Mentha piperita, L.

Puccinia evadens, Hark.

On Baccharis viminia, DC., and associated with Coleospor ium Baccharidis, C. & H.

Puccinia, Sp.

Upon Audibertia grandiflora Benth. Undo spores light orange 25-36 *u* Teleutospores 35-50 *u*, stipe very long and up per surface of free end of spore dark. This species is very unlike P. nigrescens, Pk., which Dr. Harkness reports on Audbertia incana, Benth., and Dr. Kellerman contributes to N. A. F. (1458) on Salvia lanceolata, Willd.

Æcidium Epilobii, DC.

On seedling epilobium.

Æcidium Thalictri, Grev.

On Thalictrum Fendleri, Engl.

Æcidium Phaceleæ, Pk.

On Phacelia ramosissima. Doug. This was the most common "cluster cup" in Southern California. Dr. Harkness mentions the species on P. circinata, Jacq., at Yosemite, 1883. The present one may be a new host.

Æcidium Ranunculacearum, DC.

On unknown Ranunculus.

Æcidium roestelioides, E. & E.

On Sidalcea.

Melampsora betulina, Pers.

On Alnus rhombifolia, Nutt.

Coleosporium Bacharidis, C. & H.

On Baccharis viminea, DC., and B. pilularis, DC. This was a common and interesting rust which flourishes upon the leaves and branches of the hosts. Sometimes it makes large distortions and continues to grow from year to year, spreading up and down the stem from the swollen, knotty, infested part. Specimens were obtained where the distortion was four inches in diameter and a foot or more long, the stem below being less than half that thickness. The fungus is also interesting in its association with Puccinia evedens, Hark., when infesting the leaves.

Uredo, Sp.

On Artemesia Ludoviciana, Nutt.

Uredo.

On various grasses.

Phyllachora Trifolii, Pers.

On Trifolium Sp., near streams.

Darluca filum, Cast.

On uredo of Phragmites communis Trin.

Ramularia, Sp.

On Sambucus glauca, Nutt. This differs from Ramulina sambucina, Sacc.

Ramularia Urticæ, Ces.

On Urtica halosericea, Nutt.

Ramularia obovata, Fel.

On Rumex, Sp.

Ovularia orata, Sacc.

On Salvia, Sp.

Cercospora rosæcola, Pois.

On Rosa Californica.

Cercospora Callæ.

On Richardia Africana.

Cercospora vicinella, Saac.

On Ricinus communis L.

Cercospora Residæ, Fl.

On Resida odorata.

Cercospora rubigo, C. & H.

On clematis ligusticifolia, Nutt.

Cercospora, Sp.

On Ambrosia psilostachya, DC.

Stigmella Platani, Fl.

On Platanus racemosa.

Antennaria Elæophilla, Mont.

On Cult olive leaves.

Septoria cerasina, Pk.

On peach and apricot, causing the so-called "gum shot" injury. Very abundant and therefore a destructive fungus in the orchards.

Septoria Rubi.

On Rubus ursenus, C. & S.

Septoria Epilobii, Mont.

Epilobium, Sp.

Septoria, Sp.

On Laverbera assurgent flora, Kelty.

Septoria artemeseæ, Pass.

On Artemesia Ludoviciana, Nutt.

Phyllosticla, Sp.

On Solanum nigrum var Douglasii, Gray.

Phyllosticla phomae formis, Sacc.

On Quercus agrifolia, Nee.

For the determinations of some of the more difficult species, thanks are here expressed to Dr. H. W. Harkness who kindly aided in the work.

It is intended to furnish a full index of all matter in the bulletins, after two more numbers are issued.

The article on "Three Nuclei in Pollen Grains", (page 86), appeared in nearly its present form in the *Botanical Gazette* for last December, and the one upon "Downy Mildews in a Dry Season", (page 95), is in the last issue (March) of the same journal.